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for the

MODEL DMX1

ULTRASONIC PULSE-ECHO THICKNESS GAGE WITH DIGITAL THICKNESS/VELOCITY READOUT

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Krautkramer Branson

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MODEL DMX1

ULTRASONIC PULSE-ECHO THICKNESS GAGE
WITH
DIGITAL THICKNESS/VELOCITY READOUT

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When used in accordance with the manufacturer's written instructions and under normal operating conditions KRAUTKRAMER BRANSON (KB) test instruments are guaranteed to be free from defects in material and workmanship for a period of one (1) year from date of shipment. KB will repair free of labor and material charges any unit which proves defective within one year from date of original shipment by KB or by an authorized representative or distributor.

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Mifflin County Industrial Park
P. O. Box 350
Lewistown, PA 17044
Telephone: 717-242-0327 (or)
717-242-0331
Telex: 842-354

Comments or questions concerning this manual should be directed to:

Thickness Gauge Product Manager
Krautkramer Branson
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Lewistown, PA 17044
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LIST OF EFFECTIVE PAGES

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IMPORTANT NOTICE

READ THE FOLLOWING INFORMATION PRIOR TO USE OF ANY KRAUTKRAMER BRANSON INSTRUMENTS.

A FAILURE TO READ AND UNDERSTAND THE FOLLOWING INFORMATION WILL CAUSE ERRORS TO OCCUR DURING USE OF THE INSTRUMENT. SUCH ERRORS MAY, IN TURN, LEAD TO PROPERTY DAMAGE OR PERSONAL INJURY.

GENERAL WARNINGS

Proper use of ultrasonic test equipment requires three essential elements:

- Selection of the correct testing equipment.
- Knowledge of the specific "test application requirements."
- Training on the part of the instrument operator.

This operating manual provides instruction in the basic set-up and operation of the test equipment. There are, however, additional elements which affect the proper use of ultrasonic test equipment. Specific information regarding these additional elements is beyond the scope of this manual. The operator should refer to textbooks on the subject of ultrasonic testing for more detailed information.

OPERATOR TRAINING

Operators must receive adequate training before using ultrasonic test equipment. Operators must be trained in general ultrasonic testing procedures and in the set-up and performance required by a particular test. Operators must understand:

- Soundwave propogation theory.
- Effects of the velocity of sound of the test material.
- Behavior of the soundwave where two different materials are in contact.
- Areas covered by the sound beam.

If the operator lacks this basic knowledge, the operator may receive and rely upon incorrect data. Property damage or personal injury may result.

More specific information about operator training, qualification, and certification is available in ASNT-TCIA and in many other industry specifications.

TEST APPLICATION REQUIREMENTS

Every ultrasonic test has certain test application requirements. These include:

- Determination of what is to be tested.

- Selection of a suitable test technique.

- Evaluation of test material conditions.

- Selection of acceptance/rejection limits.

Operators must be informed of the test application requirements before testing by those responsible for the product. Previous experience with the test material is the best basis for determining test application requirements. Additional information concerning test specifications and procedures is available from various Technical Societies, Industry Groups, and Government Agencies.

TESTING LIMITATIONS

In ultrasonic testing, information is obtained only from within the limits of the sound beam. Operators must exercise great caution in making inferences about the test material outside the limits of the sound beam. For example, when testing large material it may be impossible or impractical for the operator to perform a complete, one hundred percent inspection. When less than a complete inspection is to be performed, the operator must be shown the specific areas to inspect. When data from these areas are evaluated, qualified quality assurance personnel may use statistical and probability techniques to make inferences about areas not inspected.

Sound beams reflect from the first interior surface encountered. Because of part geometry and overlapped flaws or overlapped surfaces, reflections from hidden flaws or surfaces may go undetected. Operators must take steps to assure that the entire thickness of the test material is being examined.

ULTRASONIC THICKNESS MEASUREMENTS WARNINGS

Ultrasonic thickness measurement is the mathematical result of multiplying the velocity of sound in a material by the transit time of the soundwaves traveling through the material. Prior to use, the instrument is calibrated to the material's sound velocity. The instrument measures the transit time and displays a thickness value by multiplying the sound velocity and transit time.

VELOCITY OF SOUND

Accurate ultrasonic thickness measurement and flaw location depend upon the velocity of sound in the material. The velocity of sound varies because of characteristics of the test material. Velocity is not affected by the test instrument. Before testing begins, the operator must calibrate the instrument to the velocity of sound of the test material. The manual describes how to calibrate the instrument when the velocity of sound is known. If the velocity of sound is not known, the instrument can still be calibrated if a sample of the test material with known thickness is available.

Ultrasonic instruments work by assuming that the velocity of sound is uniform in the test material. Sometimes, however, the test material's velocity of sound is not uniform. The instrument should, therefore, be recalibrated from time to time to check that the velocity of sound of different tested parts is the same. If the instrument is not recalibrated, the operator may receive erroneous measurements which could result in property damage or personal injury.

TEMPERATURE DEPENDENCE

Velocity of sound of the test material is affected by the material's temperature. When testing a material subject to different temperature's, the operator should frequently recalibrate the instrument using a sample at the test temperature.

Temperature differences can also affect the probe delay line and the instrument itself. Frequent recalibration of the test instrument at the test temperature will reduce errors caused by temperature variations.

TESTING CORROSIVE AREAS

Ultrasonic testing of materials subject to corrosion, erosion, and pitting requires special attention. Operators should consider both previous experience and calculations for determining highly corrosive areas so as to achieve error-free measurements.

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Figure 1-1. DMX1 Ultrasonic Thickness Gauge

CHAPTER 1

INTRODUCTION

1-1. INTRODUCTION

1-2. This manual contains the Operating and Maintenance Instructions for the Model DMX1 Ultrasonic Thickness Gauge (see figure 1-1), hereinafter called DMX or DMX1, manufactured by Krautkramer Branson, Lewistown, Pennsylvania.
This manual is divided into five chapters which are listed below:

Chapter	Title
1	Introduction
2	Preparation for Use
3	Operating Instructions
4	Theory of Operation
5	Maintenance Instructions
6	Parts Lists

1-3. PURPOSE AND USE

The DMX is an ultrasonic thickness measuring device capable of taking very accurate measurements of metal and plastic and similar types of materials. Its principal advantage over more common thickness measuring tools, such as the micrometer, is that only one side of the material need be accessible. In many instances, the DMX will permit nondestructive thickness measurements in situations which otherwise would not permit measurement without cutting or in some way damaging the workpiece itself. The basic limitation of the DMX, and this applies to all ultrasonic thickness measurement devices, is the material to be measured must be capable of conducting sound. Typical uses of the DMX are measurement of wall thickness of metal tubing, plastic pipe, etc.

1-5. DESCRIPTION

1-6. The DMX is housed in a durable aluminum case with a carrying strap. A small screwdriver is attached to the carrying strap, and is used to remove the battery pack assembly. The molded polycarbonate battery pack assembly resists impact and heat. The DMX is normally supplied with five Nickel Cadmium (NiCad) rechargeable batteries. The optional battery charger assembly provides the power to recharge the batteries. Special features of the DMX are itemized below:

- Automatic zero correction. Calibration is a single point setup.

- Quick calibration check. Press a button to display material velocity. Displayed value indicates if the instrument calibration is correct.

- Coupling check. Symbol in the display indicates if the probe is properly coupled to the material.

- In addition to the normal mode of operation, the DMX can operate in the following modes:

  a. High Speed - DMX can be used to scan or survey a workpiece for minimum thickness. DMX will hold and display the minimum thickness measured for approximately three seconds or until a smaller thickness is detected.

  b. Normal Differential - DMX displays the difference between the measured thickness and an operator selected, nominal value. This difference is displayed in a + or - format. This mode is useful for quick quality control checks.

  c. High Speed Differential - DMX holds and displays the maximum negative difference detected between the measured thickness an operator preset value. This maximum difference will be displayed as a - value and this reading will be held for approximately three seconds or until a greater negative difference is detected.

  d. High Set/Low Set Limits - An alarm symbol and the thickness reading will blink if measured thickness is greater than the operator preset high set value or if the measured thickness is less than the operator preset low set value.

- Automatic turn-off feature. To conserve battery power, the display is automatically turned off if no reading is taken for approximately four minutes.

- DMX can display measured thickness in either "inches" or "mm".

- An automatic backlight for easy viewing of the display in low light conditions, activated by a photocell only when probe is coupled to test piece.

- Over temperature warning in display when temperature of test piece exceeds recommended range of the DX series probe being used.

Table 1-1 lists the equipment supplied with the DMX.

1-7. TECHNICAL DATA AND SPECIFICATIONS

1-8. Table 1-2 lists the DMX1 technical data and specifications. Table 1-3 lists the probe technical data and specifications.

Table 1-1. Equipment Supplied

Qty.	Designation	Description	KB Part No.
1	DMX1	Ultrasonic Thickness Gauge	023-503-520
1	C-DX	Probe Cable Assembly	
1	DX-101	Standard Probe	113-544-101
*	HP-DX	HPIL Interface	
*	BC-560	Battery Charger Assembly	

*Optional

Table 1-2. DMX1 Technical Data and Specifications

Item	Description
Measuring Range: At room temperature. Actual range dependent upon test material velocity and attenuation factor of test material.	0.020" to 9.999" (0.5 mm to 254 mm) flat surfaces, rougher than 50 micro-inches (carbon steel). 0.040" to 5.000" (1.0 mm to 125 mm) flat surfaces, rougher than 50 micro-inches (gray cast).
Resolution	0.001" (0.1 mm)
Material Velocity Range	Up to 9999 x 10^2 inches/second (Up to 9999 x m/second)
Display Update Rate	3 Hz
Linearity	±0.002" (±0.1 mm) over the specified measuring range of any DMX1 probe at constant ambient temperature.
Reading Stability	Thickness readings taken on a 1" (25.4 mm) carbon steel test block will not vary by more than ±0.002" (±0.1 mm) for each variation of 45°F (25°C) in instrument temperature. Thickness readings taken on a 1" (25.4 mm) carbon steel test block will not vary more than ±0.002" (±0.1 mm) as the contact temperature is cycled through its entire range (see table 1-3).
Repeatability	With the DMX calibrated on a 1" (25.4 mm) carbon steel test block and the material velocity value unchanged, the repeatability is ±0.001" (±0.1 mm). With the DMX calibrated on a 1" (25.4 mm) carbon steel test block and the material velocity value recorded and then the material velocity value changed and returned to its original value, the repeat-ability is ±0.001" (±0.1 mm).

Table 1-2. DMX1 Technical Data and Specifications (Cont'd)

Item	Description
Curved Surfaces (surface smoother than 50 micro-inches at ambient temperature	The DMX can make thickness measurements on curved surfaces within the limits listed below: Radius of Curvature / Wall Thickness Range 2.000" (50 mm) — 0.030" to 1.000" (0.75 mm to 25.0 mm) 1.000" (25 mm) — 0.040" to 0.500" (1.0 mm to 12.0 mm) 0.500" (12 mm) — 0.045" to 0.2500" (1.2 mm to 6.0 mm) 0.300" (8 mm) — 0.050" to 0.1250" (1.3 mm to 3.0 mm)
DMX Operating Temperature	15°F (-10°C) to 130°F (55°C)
DMX Storage Temperature	-13°F (-25°C) to 140°F (60°C)
Temperated Range of Material to be Measured (Contact Temperature)	Dependent upon probe being used (see table 1-3).
Operating Time	The DMX1 operating time is dependent upon the mode of operation and the type of batteries being used as listed below: Battery Type / Mode of Operation / Operating Time NiCad — Normal — 40 hours NiCad — High Speed — 8 hours Alkaline — Normal — 100 hours Alkaline — High Speed — 20 hours
Battery Recharge Time	14 hours.

Table 1-2. DMX1 Technical Data and Specifications (Cont'd)

Item	Description
Physical Size: Width Height Depth Weight (including batteries but excluding probe and probe cable)	 2.75" (70 mm) 6.25" (159 mm) 1.50" (38 mm) 21 ounces (0.7 Kg)

Table 1-3. Probe Technical Data and Specifications

Probe	Nominal Frequency (MHz	Contact Diameter	Contact Temperature Range	Measuring Range (Steel*)
Standard (DX-101)	5.0	0.375" (9.5 mm)	15°F to 450°F (-10° to 230°C)	0.050" to 9.999" (1.2 mm to 254.0 m
Penetration (DX-103)	1.0	1.0" (25.4 mm)	15°F to 130°F (-10°C to 54°C)	0.2" minimum to 9.999" (5.0 mm minimum to 254.0 m
High Temperature (DX-109)	5.0	0.433" (11.0 mm)	400°F to 1100°F (200°C to 590°C)	0.100" to 5.000" (2.5 mm to 127.0 m
Fingertip (DX-105)	5.0	0.25" (6.4 mm)	15°F to 130°F (-10°C to 54°C)	0.030" to 3.000" (0.7 mm to 76.0 mm
Boiler Tube (DX-107)	5.0	0.25" (6.4 mm)	15°F to 130°F (-10° to 54°C)	0.030" to 3.000" (0.7 mm to 76.00 m
High Sensitivity	5.0	0.25" (6.4 mm)	15°F to 130°F (-10°C to 54°C)	0.030" to 3.000" (.8 mm to 76.0 mm)

*Material velocity of steel = 2300 x 10^2 inches/second
(5920 m/second)

(Chg. 1)

CHAPTER 2

PREPARATION FOR USE

2-1. INTRODUCTION

2-2. This chapter contains the instructions to unpack the DMX, check the DMX for in-shipment damage, and to prepare the DMX for use.

2-3. UNPACKING

2-4. The DMX and accessories are shipped in a cardboard shipping container. To unpack the shipping container, proceed as follows:

a. Carefully open cardboard shipping container.

b. Remove styrofoam shipping container from cardboard shipping container.

c. Remove DMX, accessories, and packing materials from styrofoam shipping container.

d. Check the contents against the shipping list.

e. Save all packing materials and the styrofoam shipping container for possible reshipment.

2-5. CHECK FOR IN-SHIPMENT DAMAGE

2-6. After unpacking the instrument and accessories, visually inspect the instrument and accessories for evidence of damage. If damage is discovered, do not use the instrument, a claim should be filed immediately with the carrier, and Krautkramer Branson should be notified of such action. As a guide, inspect the instrument and accessories as described below:

a. Check for dents, cracks, and other evidence of mishandling.

b. Check all components for security of mounting and loose hardware.

c. Check all connectors and cables for loose, broken, or missing contacts; and cut, frayed, or damaged insulation.

d. Check all controls for proper mechanical operation.

2-7. PREPARATION FOR USE

CAUTION

Although the probes used with the DMX are all dual element, delay line probes, the probes are sealed and couplant can not be placed between the transducer face and the delay lines (a permanent couplant is applied during manufacture). Any attempt to separate the delay line from the probe will permanently damage the probe and possibly cause all measurements taken with that probe to be incorrect.

2-8. If the DMX is to be used with the standard (DX-101), penetration (DX-103), or high temperature (DX-109) probe, connect the probe cable assembly (C-DX) microdot connector to the probe microdot connector then connect the probe cable assembly (D-DX) lemo connector to the DMX lemo connectors (2, figure 3-1). If the DMX is to be used with the fingertip (DX-105), boiler tube (DX-107), or high sensitivity (DX-111) probe, connect the probe cable lemo connector to the DMX lemo connectors.

2-9. The DMX after being unpacked and checked and the probe connected is ready for use. The DMX is normally shipped with five fully charged NiCad batteries installed. If necessary, install five batteries (NiCad type AA (Everready CH-500H) or alkaline type AA) as follows:

a. Using the wrist strap key (28, figure 3-1) or a screwdriver, loosen the two captive screws (see figure 2-1) that secure the battery pack assembly (see figure 2-1) to the DMX1 case assembly (see figure 2-1).

b. Carefully pull battery pack assembly out of DMX1 case assembly.

c. Install five fully charged NiCad or five new alkaline batteries in the battery pack assembly. Insure that batteries are installed with proper polarities (see figure 2-1). Do not install battery pack assembly in the DMX1 case at this time, proceed to the cold start-up procedure of paragraphs 3-12.

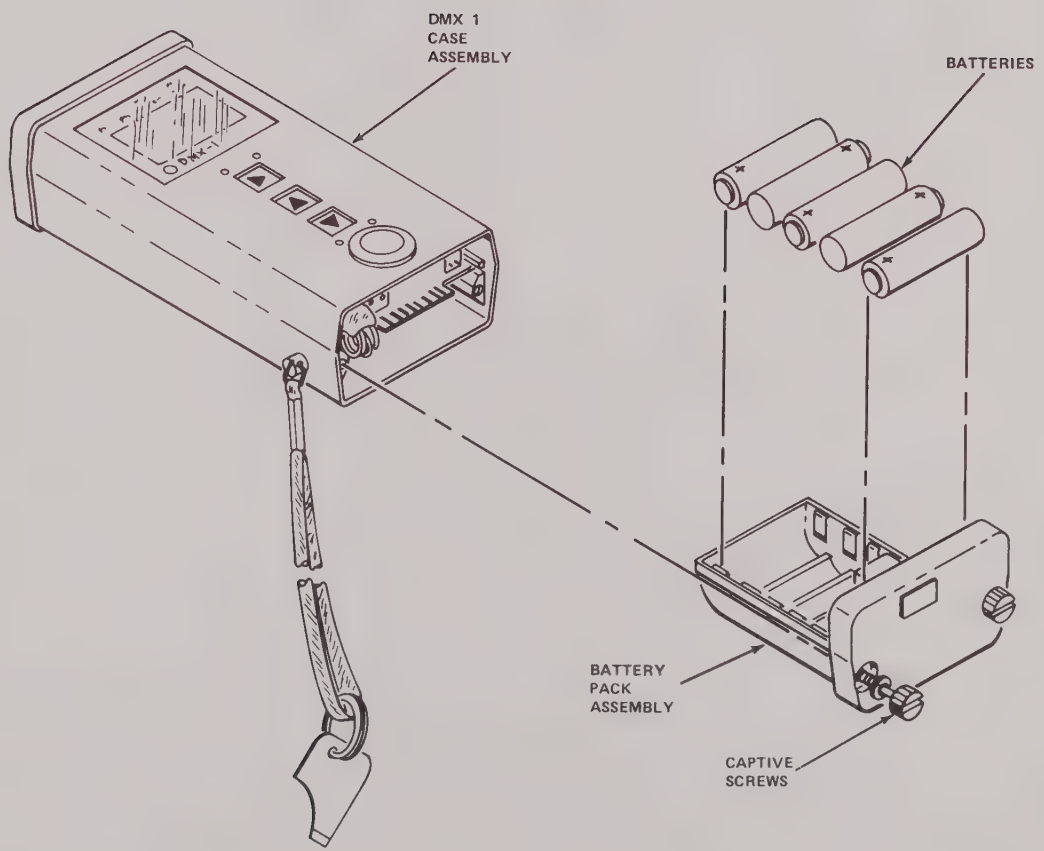

Figure 2-1. Battery Installation and Replacement

CHAPTER 3

OPERATING INSTRUCTIONS

3-1. INTRODUCTION

3-2. This chapter contains the information pertaining to the DMX controls and indicators, couplant, probe selection, DMX operation, making thickness measurements, optional battery charger assembly operation, battery care, and battery replacement.

3-3. CONTROLS AND INDICATORS

3-4. Table 3-1 lists and describes the DMX controls and indicators which are illustrated in figure 3-1.

Table 3-1. Controls and Indicators

Control or Indicator	Figure 3-1 Index No.	Function
Probe Lemo Connectors	2	Provides means to connect probe cable to DMX.
Ambient Light Level Sensor	3	Detects when ambient light level decreases below a predetermined level which causes the display (10) back light to light when probe is coupled to test piece.
CAL (Calibration) Pushbutton Switch	1	When depressed, causes the CAL indicator (18) to light or go out. When the CAL display indicator is lighted, the increment pushbutton switch (22) and decrement pushbutton switch (23) are enabled which allows the material velocity (MAT'L) (4), thickness (NORM) (5), low set point (LO SET) (8), or high set point (HI SET) (9) values displayed on display (10), as determined by function selection by the function push-button switch (21), to be entered and changed as required.
MAT'L (Material Velocity)	4	When the carat below MAT'L is lighted (controlled by function pushbutton switch (21)), the display (10) displays the material velocity to which the DMX has been calibrated to (CAL indicator (18) not lighted) or adjusted to (CAL indicator (18) lighted).
NORM (Normal-Thickness Indication)	5	When the carat below NORM is lighted (controlled by function pushbutton switch (21)), the display (10) displays the thickness to which the DMX has been calibrated to (CAL indicator (18) not lighted) or adjusted to (CAL indicator (18) lighted.

Table 3-1. Controls and Indicators (Cont'd)

Control or Indicator	Figure 3-1 Index No.	Function
HI SPD (High Speed - Operation in this mode depletes the batteries approximately four times faster than the NORM mode)	6	When the carat below HI SPD is lighted (controlled by function pushbutton switch (21)), the display (10) will hold and display the minimum thickness measured for approximately three seconds or until a smaller thickness value is measured.
NORM DIFF (Normal Differential)	5 and 7	When the carats below NORM (5) and DIFF (7) are lighted (controlled by function push-button switch (21)), the display (10) displays the preset value (CAL indicator (18) lighted) or the difference (+ or -) between the measured thickness and the preset value (CAL indicator (18) not lighted).
HI SPD DIFF (High Speed Differential - Operation in this mode depletes the batteries approximately four times faster than the NORM mode)	6 and 7	When the carats below HI SPD (5) and DIFF (7) are lighted (controlled by function push-button switch (21)), the display (10) displays the preset value (CAL indicator (18) lighted) or the greatest negative difference between the measured thickness and the preset value (CAL indicator (18) not lighted). The display (10) will hold and display the maximum positive or negative difference measured for approximately three seconds or until a greater difference is measured.
LO SET (Low Limit Set Point)	8	When the carat below LO SET is lighted (controlled by function pushbutton switch (21)) and the CAL indicator (18) is lighted,

Table 3-1. Controls and Indicators (Cont'd)

Control or Indicator	Figure 3-1 Index No.	Function
LO SET (Low Limit Set Point) (Cont'd)	8	the low limit set point can be entered using the increment pushbutton switch (22) and decrement pushbutton switch (23).
HI SET (High Limit Set Point)	9	When the carat below HI SET is lighted (controlled by function pushbutton switch (21)) and the CAL indicator (18) is lighted, the high limit set point can be entered using the increment pushbutton switch (27) and decrement pushbutton switch (23).
Display	10	Liquid Crystal Display (LCD)
Question Mark (Overrange Indicator)	11	Lights when thickness being measured exceeds 9.999" (display (10) indicates last four digits of measured thickness (ex.: thickness 10.493", display (10) indicates ? 0.493").
		WARNING Any measurement observed, when overrange (?) indicator is lighted, is invalid.
+ or - Indicator	12	Plus or minus indicator for NORM DIFF (5 and 7) mode and HI SPD DIFF (6 and 7) mode.
Alarm Indicator	13	Lights when the NORM (5) measured thickness is below the LO SET (8) low limit set point value or when the NORM (5) measured thickness is above the HI SET (9) high limit set point value.

Table 3-1. Controls and Indicators (Cont'd)

Control or Indicator	Figure 3-1 Index No.	Function
Low Battery Indicator	14	Lights when batteries should be recharged (NiCad) or replaced (alkaline).
Non-standard Probe Indicator	15	Lights to indicate that a probe other than an approved DX series probe is connected to the DMX.
TEMP Indicator	16	Over temperature warning. Lights to indicate that the temperature limit of the probe connected to the DMX has been exceed. When lighted uncouple probe immediately from work piece to prevent damage to the probe. Operates only with DX series probes.
Coupling Indicator	17	Lights when probe is properly coupled to the test piece.
CAL Indicator	18	Controlled by CAL pushbutton switch (1) refer to items 1, 4, 5, 6, 5 and 7, 6 and 7, 8, and 9 for information pertaining to this indicator.
MM Indicator	19	Lights to indicate that display (10) measurements are in millimeters. Controlled by depressing increment pushbutton switch (22) and decrement push-button switch (23) simultaneously.
IN Indicator	20	Lights to indicate that display (10) measurements are in inches. Controlled by depressing increment pushbutton switch (22) and decrement push-button switch (23) simultaneously.

Table 3-1. Controls and Indicators (Cont'd)

Control or Indicator	Figure 3-1 Index No.	Function
Function Pushbutton Switch	21	When depressed, changes the selected operating mode of the DMX. The functions change in the following sequence: MATL (4) NORM (5) HI SPD (6) NORM DIFF (5 and 7) HI SPD DIFF (6 and 7) LO SET (8) HI SET (9)
Increment Pushbutton Switch	22	Enabled when CAL indicator (18) is lighted. If depressed momentarily, increments display (10) indication by one count. If held depressed, increments display (10) indication slowly for approximately three seconds then increments indication rapidly.
Decrement Pushbutton Switch	23	Enabled when CAL indicator (18) is lighted. If depressed momentarily, decrements display (10) indication by one count. If held depressed, decrements display (10) indication slowly for approximately three seconds then increments indication rapidly.
AUTO ZERO Test Block	24	0.25 inch stainless steel test block.
Battery Pack Assembly Battery Charger Connector Cover	25	Covers battery pack assembly battery charger connector.
Battery Pack Assembly Battery Charger Connector	26	Provides means to connect battery charger assembly to battery pack assembly.

Table 3-1. Controls and Indicators (Cont'd)

Control or Indicator	Figure 3-1 Index No.	Function
Wrist Strap	27	Provides means to carry DMX.
Wrist Strap Key	28	Provides means to loosen battery pack assembly captive screws.

3-5. COUPLANT

CAUTION

Although the probes used with the DMX are all dual element, delay line probes, the probes are sealed and couplant can not be placed between the transducer face and the delay lines (a permanent couplant is applied during manufacture). Any attempt to separate the delay line from the probe will permanently damage the probe and possibly cause all measurements taken with that probe to be incorrect.

3-6. In order for ultrasound emitted by the probe to enter a test piece, the air between the probe and test piece must be removed. This is best done by using a liquid coupling medium, called a "couplant". Lightweight machine oil, water and glycerin work well, but in many cases are harmful to the test piece or leaves an undesirable residue. Exosen couplant is recommended. It is a product of KB Aerotech Laboratories, Division of Krautkramer Branson, P. O. Box 350, Lewistown, Pennsylvania 17044, U.S.A., and it is available in several viscosities. Exosen 7 is the lightest, least viscous grade, equivalent (approximately) to SAE 10 oil. Exosen 10 (SAE 30), Exosen 14 (SAE 40), and Exosen 20 (SAE 90) are progressively more viscous. Exosen 30 is still pourable, while Exosen 40 is semi-solid. All Exosen grades are water soluble, antiseptic, non-irritating, and pleasantly scented. They are non-toxic, non-flammable, sulphur-free, halogen-free and dry to inert particles that can be easily removed. The higher viscosity grades are recommended for overhead or vertical surfaces where runoff is a problem. Your local Krautkramer Branson sales engineer or representative can supply Exosen for you.

3-7. When measuring the thickness of materials whose temperature is greater than 150°F (65°C) a special high temperature couplant should be used. Hitempco couplant is recommended. It is a product of KB Aerotech Laboratories, Division of Krautkramer Branson, P. O. Box 350, Lewistown, Pennsylvania 17044, U.S.A.; and its part no. is XH-010. Your local Krautkramer Branson sales engineer or representative can supply Hitempco couplant for you.

3-8. PROBE SELECTION

3-9. The DMX is normally supplied with a standard probe (DX-101). However, a total of six probes are available for use with the DMX. These probes cover various measuring ranges and contact (test piece surface) temperature ranges. Table 3-2 lists and describes the probes available for use with the DMX.

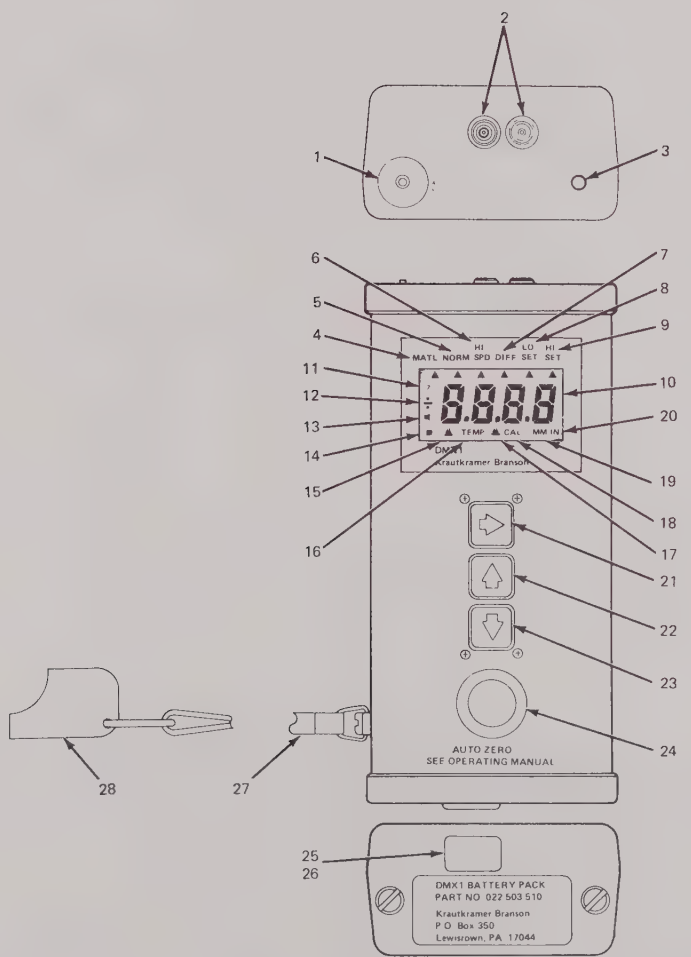

Figure 3-1. Controls and Indicators

3-10. OPERATING THE DMX

3-11. The following paragraphs contain the DMX operating procedures. These procedures are listed below:

Procedure	Para. No.
Cold Start-Up	3-12
Wake-Up (Auto Zero)	3-14
DMX Calibration with a DMX Type Probe	3-16
When the acoustic velocity of the material to be measured is known	3-18
Using a test piece of known thickness	3-19
DMX Zero Adjust and Calibration with a Non-DMX Type Probe	3-20
Operating Procedures	3-22
Material Mode	3-24
Normal Mode	3-25
High Speed Mode	3-26
Normal Differential Mode	3-27
High Speed Differential Mode	3-28

NOTE

The number in parenthesis ( ) following an indicator or control name is the figure 3-1 index number of the control or indicator. The number in parenthesis ( ) following an inch value is the metric equivalent.

Table 3-2. Probes Available for Use with the DMX

Probe	Nominal Frequency (MHz)	Contact Diameter	Contact Temperature	Measuring Range (Steel*)	Recommended Usage
Standard (DX-101)	5.0	0.375" (9.5 mm)	15°F to 450°F (-10°C to 230°C)	0.050" to 9.999" (1.2 mm to 254 mm)	General thickness gauging applications; pipes, tanks, pressure vessels, plates, ships hulls, heavy equipment maintenance, etc.
Penetration (DX-103)	1.0	1.0" (25.4 mm)	15°F to 130°F (-10°C to 54°C)	0.2" minimum to 9.999" (5.0 mm minimum to 254 mm)	Highly attenuative grainy materials; gray iron castings, cast stainless, etc.
High Temperature	5.0	0.433" (11.0 mm)	400°F to 1100°F (200°C to 590°C)	0.100" to 5.000" (2.5 mm to 127.0 mm)	High temperature pipes, tanks, reactor vessels, etc. up to 1100°F (590°C).
Fingertip (DX-105)	5.0	0.25" (6.4 mm)	15°F to 130°F (-10°C to 54°C)	0.030" to 3.000" (0.7 mm to 76.0 mm)	Small diameter pipes and tubes, wall thickness from inside pipes, and other limited access applications.
Boiler Tube (DX-107)	5.0	0.25" (6.4 mm)	15°F to 130°F (-10°C to 54°C)	0.030" to 3.000" (0.7 mm to 76.0 mm)	Studded boiler tubes and other restricted surface area applications.
High Sensitivity (DX-111)	5.0	0.25" (6.4 mm)	15°F to 130°F (-10°C to 54°C)	0.030" to 3.000" (.8 mm to 76.0 mm)	Small diameter pipes and tubes, heavy corrosion and/or pitting.

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Table 3-2. Probes Available for Use with the DMX (Cont'd)

Probe	Nominal Frequency (MHz)	Contact Diameter	Contact Temperature	Measuring Range (Steel*)	Recommended Usage
Thin Materials (DA-212) Requires KBA531 cable and TA-DX transducer adapter	10.0	0.25" (6.4 mm)	15°F to 120°F (-10°C to 49°C)	0.020" to 1.00" (0.5 mm to 25.4 mm)	Thin walled tubes, pipes, thin plates, etc. down to 0.020" (0.5 mm).

*Material velocity of steel = 2300 x 10^2 inches/second
(5920 m/second)

3-12. COLD START-UP PROCEDURE

3-13. The cold start-up procedure is performed when the battery pack assembly is inserted in the DMX, and should be performed if the DMX is suspected of malfunctioning. If the battery pack assembly is installed in the DMX remove the battery pack assembly. To remove the battery pack assembly from the DMX, loosen the two captive screws (see figure 2-1) that secure the battery pack assembly to the DMX and carefully pull the battery pack assembly out of the DMX. To perform the cold start-up procedure, refer to figure 3-2 (cold start-up procedure flow chart).

3-14. WAKE-UP (AUTO ZERO) PROCEDURE

3-15. Since the DMX does not have an on/off switch and it turns itself off four minutes after the last measurement is made, the wake-up (auto zero) procedure is used to turn on the DMX. In addition, the wake-up (auto zero) procedure automatically (under program control) zeroes the DMX when a DMX type probe is connected to the DMX or informs the operator (display (10) indicates HI) that the DMX zero adjust and calibration with non-DMX type probe must be performed. To perform the wake-up (auto zero) procedure, refer to figure 3-3 (warm-up (auto zero) procedure flow chart).

Corrections to figures 3-2 and 3-3

When coupling probe to auto zero block, display should read a value of .247, .248, .249, .250, .251, .252, or .253 in inch mode and 6.3 or 6.4 in metric mode. The carat will not be lit.

When uncoupling the probe from the auto zero block, the displayed velocity should be 2275 in inch mode and 5778 in metric mode. These values supercede the values of 2322 in and 5898 mm shown in figures 3-2 and 3-3.

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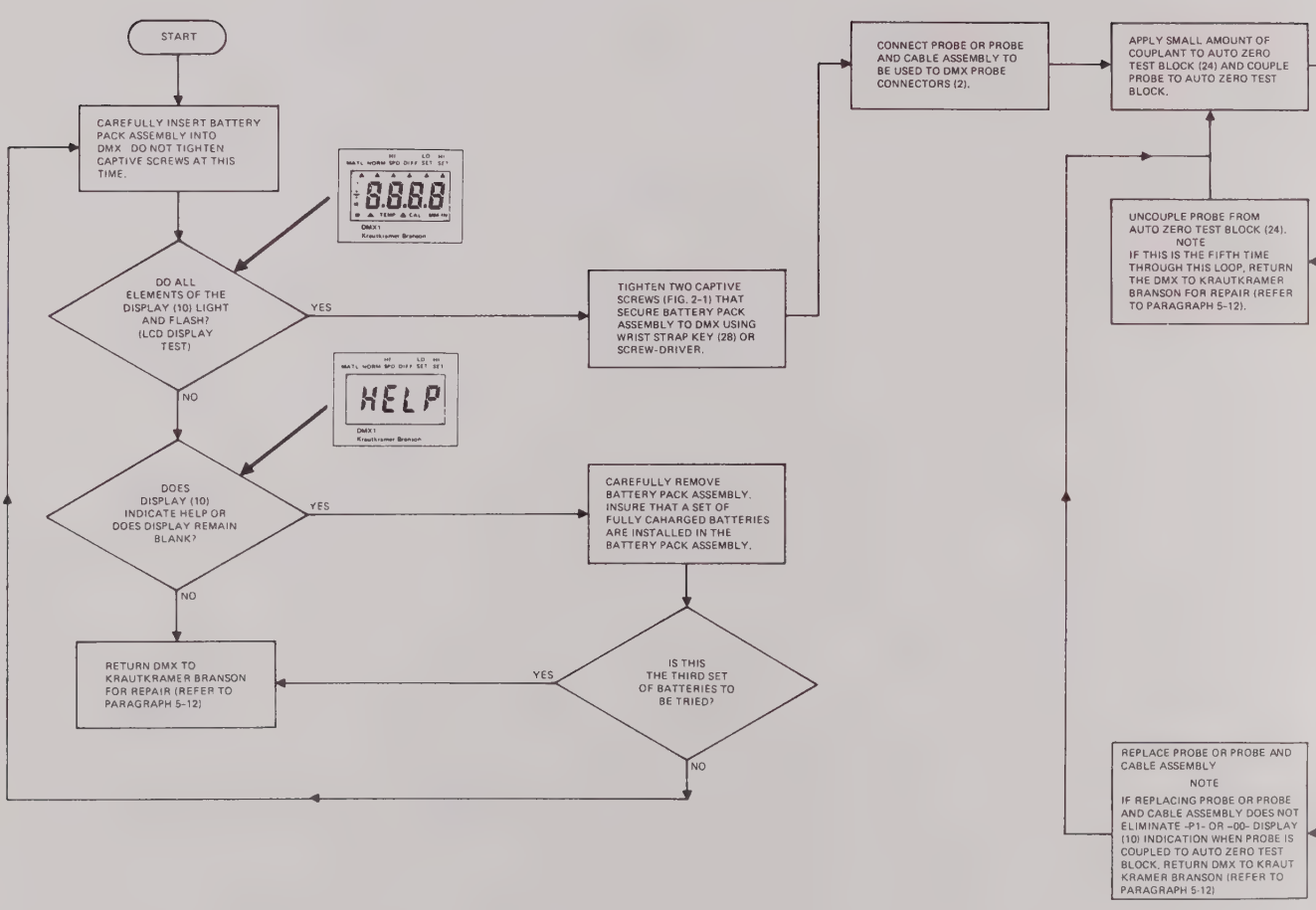

START
CAREFULLY INSERT BATTERY PACK ASSEMBLY INTO DMX DO NOT TIGHTEN CAPTIVE SCREWS AT THIS TIME.
DO ALL ELEMENTS OF THE DISPLAY (10) LIGHT AND FLASH? (LCD DISPLAY TEST)
YES
NO
TIGHTEN TWO CAPTIVE SCREWS (FIG. 2-1) THAT SECURE BATTERY PACK ASSEMBLY TO DMX USING WRIST STRAP KEY (28) OR SCREW-DRIVER.
CONNECT PROBE OR PROBE AND CABLE ASSEMBLY TO BE USED TO DMX PROBE CONNECTORS (2).
APPLY SMALL AMOUNT OF COUPLANT TO AUTO ZERO TEST BLOCK (24) AND COUPLE PROBE TO AUTO ZERO TEST BLOCK.
UNCOUPLE PROBE FROM AUTO ZERO TEST BLOCK (24).
NOTE
IF THIS IS THE FIFTH TIME THROUGH THIS LOOP, RETURN THE DMX TO KRAUTKRAMER BRANSON FOR REPAIR (REFER TO PARAGRAPH 5-12).
HELP
DOES DISPLAY (10) INDICATE HELP OR DOES DISPLAY REMAIN BLANK?
YES
NO
CAREFULLY REMOVE BATTERY PACK ASSEMBLY. INSURE THAT A SET OF FULLY CAHARGED BATTERIES ARE INSTALLED IN THE BATTERY PACK ASSEMBLY.
IS THIS THE THIRD SET OF BATTERIES TO BE TRIED?
YES
NO
RETURN DMX TO KRAUTKRAMER BRANSON FOR REPAIR (REFER TO PARAGRAPH 5-12)
REPLACE PROBE OR PROBE AND CABLE ASSEMBLY
NOTE
IF REPLACING PROBE OR PROBE AND CABLE ASSEMBLY DOES NOT ELIMINATE -P1- OR -00- DISPLAY (10) INDICATION WHEN PROBE IS COUPLED TO AUTO ZERO TEST BLOCK, RETURN DMX TO KRAUT KRAMER BRANSON (REFER TO PARAGRAPH 5-12)

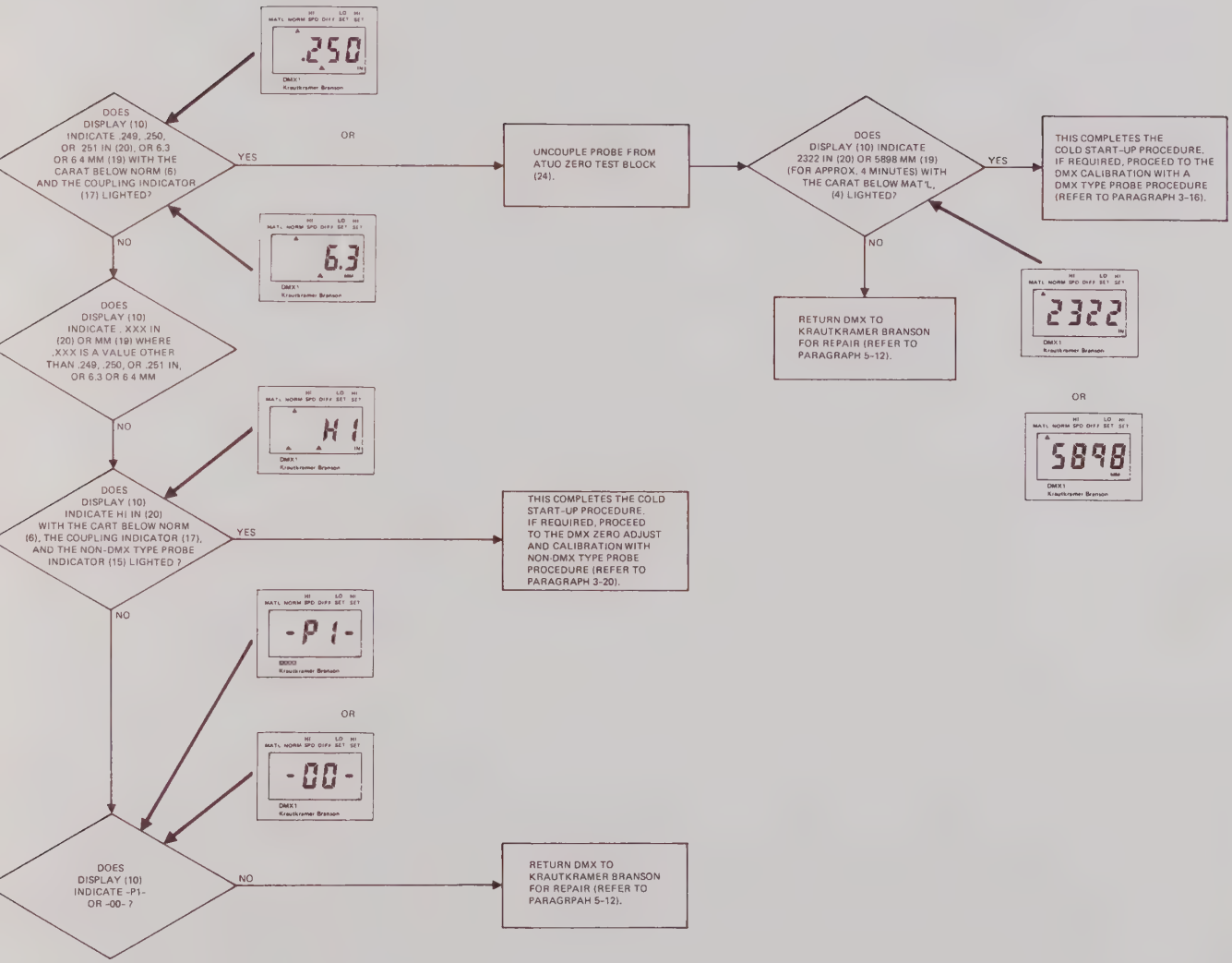
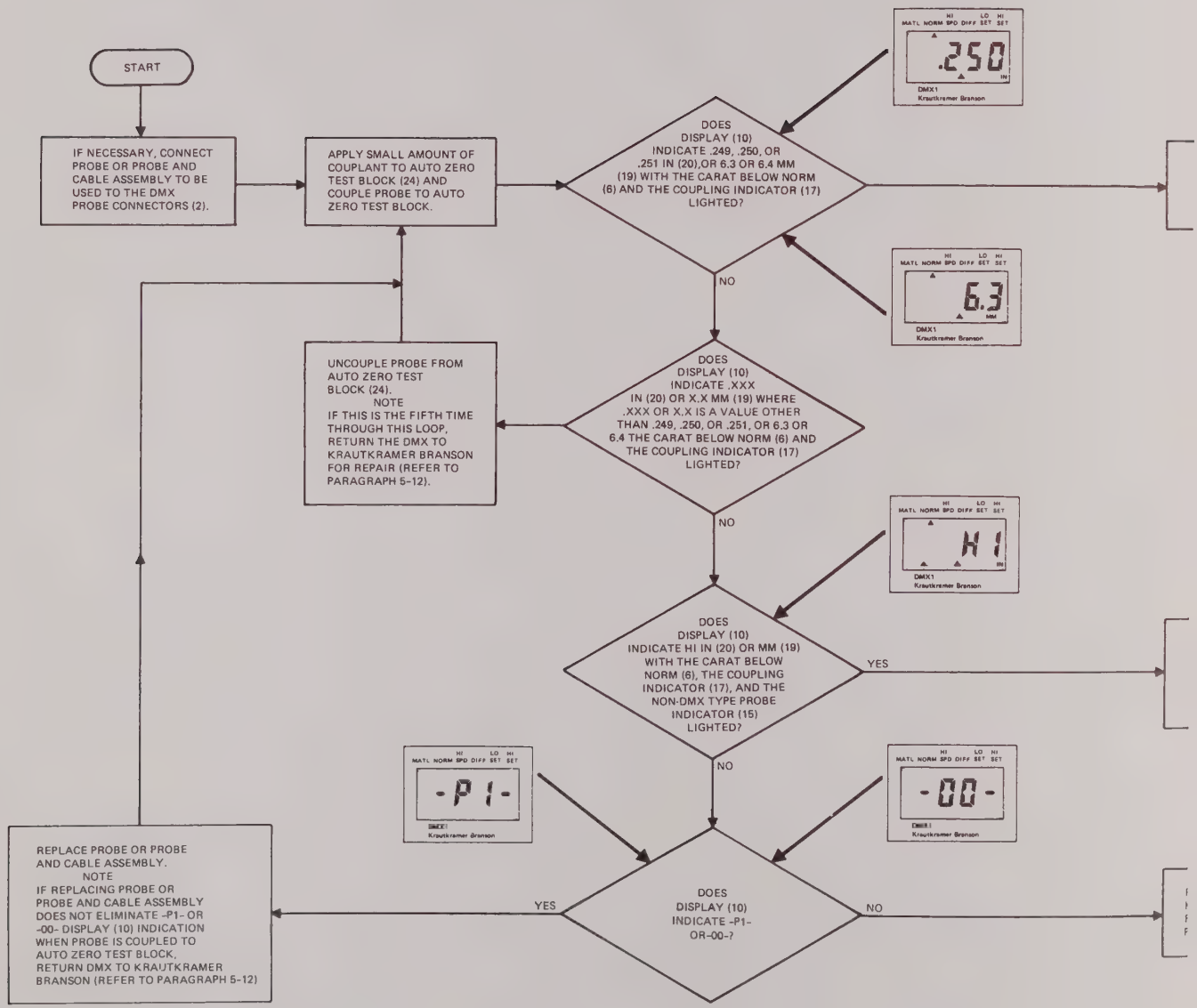

.250
DOES DISPLAY (10) INDICATE .249, .250, OR .251 IN (20), OR 6.3 OR 6.4 MM (19) WITH THE CARAT BELOW NORM (6) AND THE COUPLING INDICATOR (17) LIGHTED?
YES
OR
6.3
NO
UNCOUPLE PROBE FROM ATUO ZERO TEST BLOCK (24).
DOES DISPLAY (10) INDICATE 2322 IN (20) OR 5898 MM (19) (FOR APPROX. 4 MINUTES) WITH THE CARAT BELOW MAT'L, (4) LIGHTED?
YES
THIS COMPLETES THE COLD START-UP PROCEDURE. IF REQUIRED, PROCEED TO THE DMX CALIBRATION WITH A DMX TYPE PROBE PROCEDURE (REFER TO PARAGRAPH 3-16).
NO
RETURN DMX TO KRAUTKRAMER BRANSON FOR REPAIR (REFER TO PARAGRAPH 5-12).
2322
OR
5898
DOES DISPLAY (10) INDICATE .XXX IN (20) OR MM (19) WHERE .XXX IS A VALUE OTHER THAN .249, .250, OR .251 IN, OR 6.3 OR 6.4 MM
NO
HI
DOES DISPLAY (10) INDICATE HI IN (20) WITH THE CART BELOW NORM (6), THE COUPLING INDICATOR (17), AND THE NON-DMX TYPE PROBE INDICATOR (15) LIGHTED ?
YES
THIS COMPLETES THE COLD START-UP PROCEDURE. IF REQUIRED, PROCEED TO THE DMX ZERO ADJUST AND CALIBRATION WITH NON-DMX TYPE PROBE PROCEDURE (REFER TO PARAGRAPH 3-20).
NO
-P1-
OR
-00-
DOES DISPLAY (10) INDICATE -P1- OR -00- ?
NO
RETURN DMX TO KRAUTKRAMER BRANSON FOR REPAIR (REFER TO PARAGRPAH 5-12).

Figure 3-2. Cold Start-up Procedure Flow Chart


START
IF NECESSARY, CONNECT PROBE OR PROBE AND CABLE ASSEMBLY TO BE USED TO THE DMX PROBE CONNECTORS (2).
APPLY SMALL AMOUNT OF COUPLANT TO AUTO ZERO TEST BLOCK (24) AND COUPLE PROBE TO AUTO ZERO TEST BLOCK.
DOES DISPLAY (10) INDICATE .249, .250, OR .251 IN (20), OR 6.3 OR 6.4 MM (19) WITH THE CARAT BELOW NORM (6) AND THE COUPLING INDICATOR (17) LIGHTED?
.250
6.3
NO
UNCOUPLE PROBE FROM AUTO ZERO TEST BLOCK (24).
NOTE
IF THIS IS THE FIFTH TIME THROUGH THIS LOOP, RETURN THE DMX TO KRAUTKRAMER BRANSON FOR REPAIR (REFER TO PARAGRAPH 5-12).
DOES DISPLAY (10) INDICATE .XXX IN (20) OR X.X MM (19) WHERE .XXX OR X.X IS A VALUE OTHER THAN .249, .250, OR .251, OR 6.3 OR 6.4 THE CARAT BELOW NORM (6) AND THE COUPLING INDICATOR (17) LIGHTED?
NO
HI
DOES DISPLAY (10) INDICATE HI IN (20) OR MM (19) WITH THE CARAT BELOW NORM (6), THE COUPLING INDICATOR (17), AND THE NON-DMX TYPE PROBE INDICATOR (15) LIGHTED?
YES
NO
-P1-
-00-
DOES DISPLAY (10) INDICATE -P1- OR -00-?
YES
NO
REPLACE PROBE OR PROBE AND CABLE ASSEMBLY.
NOTE
IF REPLACING PROBE OR PROBE AND CABLE ASSEMBLY DOES NOT ELIMINATE -P1- OR -00- DISPLAY (10) INDICATION WHEN PROBE IS COUPLED TO AUTO ZERO TEST BLOCK, RETURN DMX TO KRAUTKRAMER BRANSON (REFER TO PARAGRAPH 5-12)

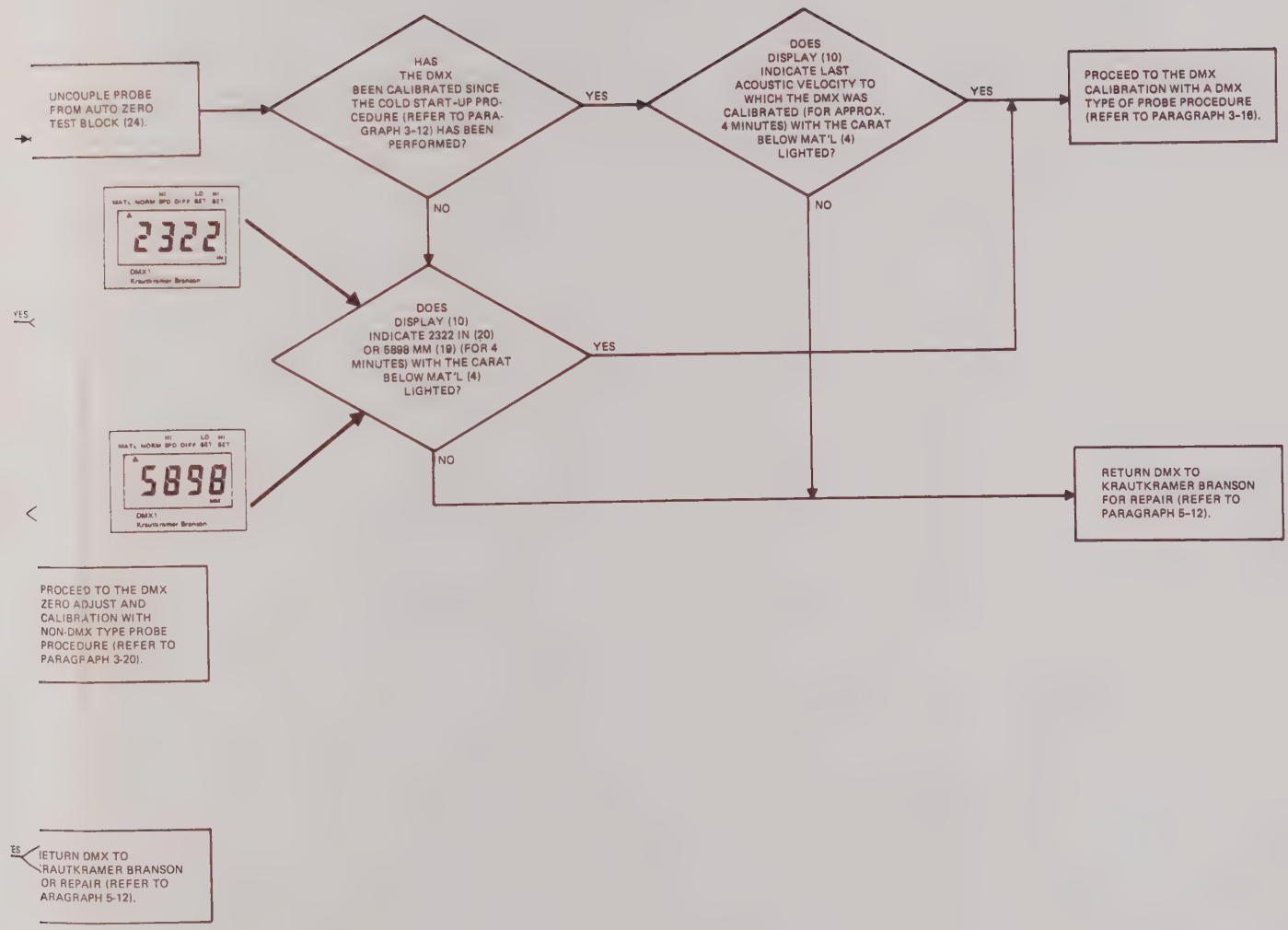

UNCOUPLE PROBE FROM AUTO ZERO TEST BLOCK (24).
HAS THE DMX BEEN CALIBRATED SINCE THE COLD START-UP PROCEDURE (REFER TO PARAGRAPH 3-12) HAS BEEN PERFORMED?
YES
NO
DOES DISPLAY (10) INDICATE LAST ACOUSTIC VELOCITY TO WHICH THE DMX WAS CALIBRATED (FOR APPROX. 4 MINUTES) WITH THE CARAT BELOW MAT'L (4) LIGHTED?
YES
NO
PROCEED TO THE DMX CALIBRATION WITH A DMX TYPE OF PROBE PROCEDURE (REFER TO PARAGRAPH 3-16).
2322
DMX1
Krautkramer Branson
DOES DISPLAY (10) INDICATE 2322 IN (20) OR 5898 MM (19) (FOR 4 MINUTES) WITH THE CARAT BELOW MAT'L (4) LIGHTED?
YES
NO
5898
DMX1
Krautkramer Branson
RETURN DMX TO KRAUTKRAMER BRANSON FOR REPAIR (REFER TO PARAGRAPH 5-12).
PROCEED TO THE DMX ZERO ADJUST AND CALIBRATION WITH NON-DMX TYPE PROBE PROCEDURE (REFER TO PARAGRAPH 3-20).
ETURN DMX TO
RAUTKRAMER BRANSON
OR REPAIR (REFER TO
ARAGRAPH 5-12).

Figure 3-3. Wake-up (Auto Zero) Procedure Flow Chart

3-16. DMX CALIBRATION WITH A DMX TYPE PROBE PROCEDURE

3-17. There are two methods to calibrate the DMX when a DMX type probe is connected. One method requires that the acoustic velocity of the material to be measured is known; the other method requires a test piece (sample) of the material that is to be measured and that the thickness of this test piece be accurately known and its temperature be the same as the material to be measured. Each of these procedures are detailed in the following paragraphs.

3-18. DMX CALIBRATION WITH A DMX TYPE PROBE WHEN THE ACOUSTIC VELOCITY OF THE MATERIAL TO BE MEASURED IS KNOWN. To calibrate the DMX with a DMX type probe when the acoustic velocity of the material to be measured is known, proceed as follows:

CAUTION

The acoustic velocity to be entered into the DMX during this procedure must be accurately known for the material and the temperature of the material to be measured.

a. If necessary, perform the wake-up (auto zero) procedure (refer to paragraph 3-14).

b. Insure that the carat under MAT'L (4) is lighted. If not, depress the Function pushbutton switch (21) as required, until the carat under MAT'L is lighted.

c. To select millimeters if the IN indicator (20) is lighted or inches if the MM indicator (19) is lighted, depress the Increment pushbutton switch (22) and the Decrement pushbutton switch (23) simultaneously.

d. If the CAL indicator (18) is not lighted, depress the CAL pushbutton switch (1) once. Observe that the CAL indicator lights.

e. Using the Increment pushbutton switch (22) and/or the Decrement pushbutton switch (23), as required, increment or decrement the display (10) indication until the display indicates the acoustic velocity to be entered. The acoustic velocity is displayed in units of x 10^2 inches/second (IN) or x 10^3 millimeter/second (MM).

f. Depress the CAL pushbutton switch (1) once. Observe that the CAL indicator (18) goes out. The calibration setting is now "locked" against accidental changes.

g. Depress the Function pushbutton switch (21) once. Observe that the carat under MAT'L (4) goes out and the carat under NORM (5) lights.

h. The DMX is now calibrated and ready to make thickness measurements on specimens or parts that have the same acoustic velocity which was just entered into the DMX. To select the desired operating mode and make thickness measurements, refer to paragraph 3-22.

3-19. DMX CALIBRATION WITH A DMX TYPE PROBE USING A TEST PIECE OF KNOWN THICKNESS. To calibrate the DMX with a DMX type probe using a test piece of known thickness, proceed as follows:

WARNING

The test piece used in this procedure must be made from the same material as that which is to be measured or equivalent (determined by the specification being used), must be at the same temperature as the material to be measured, and its actual thickness accurately known.

a. If necessary, perform the wake-up (auto zero) procedure (refer to paragraph 3-14).

b. Insure that carat under NORM (5) is lighted. If not, depress the Function pushbutton switch (21), as required, until the carat under NORM is lighted.

c. To select millimeters if the IN indicator (20) is lighted or inches if the MM indicator (19) is lighted, depress the Increment pushbutton switch (22) and the Decrement pushbutton switch (23) simultaneously.

d. If the CAL indicator (18) is not lighted, depress the CAL pushbutton switch (1) once. Observe that CAL indicator lights.

e. Apply small amount of couplant to the test piece and couple probe to test piece. Observe that Coupling indicator (17) lights and display (10) indicates a thickness.

NOTE

Once the display (10) indicates a stable thickness indication, it is not necessary to hold the probe coupled to the test piece for the remainder of this procedure. The probe may be uncoupled from the test piece at this time.

f. Using the Increment pushbutton switch (22) and/or the Decrement pushbutton switch (23), as required, increment or decrement the display (10) indication until the display indicates the thickness of the test piece.

NOTE

If it is desired to record the acoustic velocity of the test piece, repeatedly depress the Function pushbutton switch (21) until the carat under MAT'L (4) is lighted. At this time, the display (10) indicates the acoustic velocity of the test piece to which the DMX was just calibrated. The acoustic velocity is displayed in unit of x 10^2 inches/second (IN) or x 10^3 millimeters/second (MM). Then depress Function pushbutton switch once to light the carat under NORM (5)

g. Depress the CAL pushbutton switch (1) once. Observe that the CAL indicator (18) goes out. The calibration setting is now "locked" against accidental changes.

h. The DMX is now calibrated and ready to make thickness measurements on speciments or parts that have the same acoustic velocity and temperature as the test piece. To select the desired operating mode and make thickness measurements, refer to paragraph 3-22.

3-20. DMX ZERO ADJUST AND CALIBRATION WITH NON-DMX TYPE PROBE

3-21. To calibrate the DMX when a non-DMX type probe is connected to the DMX (display (10) indicates LO (operator prompt to measure thinner test piece) during wake-up (auto zero) procedure), proceed as follows:

WARNING

To calibrate the DMX when a non-DMX probe is connected, two test pieces are required. The two test pieces used in this procedure must be made from the same material as that which is to be measured or equivalent (determined by specification being used), must be at the same temperature as the material to be measured, and their actual thicknesses accurately known. For best results, select two test pieces whose thickest and thinnest dimensions bracket the range of thickness measurements to be made. The closer the thickness of the test pieces approximate the thickest and thinnest

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measurements to be made, the better the measurements will be. These thicknesses will set the upper and lower calibration limits of the DMX.

IMPORTANT NOTE

DMX V-path correction does not operate when non-DMX type transducers are used.

a. If necessary, perform the wake-up (auto zero) procedure (refer to paragraph 3-14). Observe that the display (10) indicates LO (operator prompt to measure thinner test piece).

b. To select millimeters if the IN indicator (20) is lighted or inches if the MM indicator (19) is lighted, depress the Increment pushbutton switch (22) and the Decrement pushbutton switch (23) simultaneously.

c. Apply small amount of couplant to the thinner test piece and couple probe to thinner test piece. Observe that Coupling indicator (17) lights and display (10) indicates a thickness.

d. Using the Increment pushbutton switch (22) and/or the Decrement pushbutton switch (23), as required, increment or decrement the display (10) indication until the display indicates the thickness of the thinner test piece.

e. Uncouple the probe from the thinner test piece.

f. Depress the function switch (21). Observe that the display indicates HI (operator prompt that thicker test piece is to be measured).

g. Apply small amount of couplant to the thicker test piece and couple probe to thicker test piece. Observe that Coupling indicator (17) lights and display (10) indicates a thickness.

h. Using the Increment pushbutton switch (22) and/or Decrement pushbutton switch (23), as required, increment or decrement the display (10) indication until the display indicates the thickness of the thicker test piece.

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i. Uncouple the probe from the thicker test piece.

j. Depress the function switch (21). Observe that the display (10) indicates LO (operator prompt that the thinner test piece is to be measured).

k. Repeat steps c through i until no further adjustment is required (display (10) indicates actual thickness of thicker and thinner test pieces ±1 count).

l. Depress the CAL Pushbutton switch (1) once. Observe that the CAL indicator (18) goes out. The calibration setting is now "locked" against accidental changes.

WARNING

Due to the characteristics of dual element probes, the DMX is now calibrated only to measure thicknesses within the range for which the DMX is calibrated (from thickness of thinner test piece to thickness of thicker test piece).

m. The DMX is now calibrated and ready to make thickness measurements on specimens or parts that have the same acoustic velocity and temperature as the test pieces and that are within the calibrated range (from thickness of thinner test piece to thickness of thicker test piece).

3-22. OPERATING PROCEDURES

3-23. The following paragraphs contain the material mode, normal mode, high speed mode, normal differential mode, and high speed differential mode operating procedures. In addition, prior to proceeding to the selected operating mode paragraph, it is recommended that the operator become familiar with the general operating information described below:

a. The DMX turns itself off approximately four minutes after the wake-up (auto zero) procedure is performed (if no other measurements are taken or pushbutton switches are depressed), after the last measurement is taken, or pushbutton switch is depressed.

b. In addition, after the DMX turns itself off, the operator has 10 minutes to turn on the DMX again without having to perform the wake-up (auto zero) procedure (the wake-up (auto zero) procedure may be performed during this 10 minute period). To turn on the DMX during this 10 minute period without performing the wake-up (auto zero) procedure, depress the CAL pushbutton switch (1) once. This turns on the DMX causing it to return to operation with its original zero and calibrated value for the acoustic velocity of the material to be measured, and the carat under MAT'L (4) to be lighted. Use the Function pushbutton switch to return the DMX to the desired operating mode. In addition, if the probe is disconnected from the DMX probe connectors (2) during this 10 minute period, depressing the CAL pushbutton switch will not turn on the DMX, the wake-up (auto zero) procedure must be used to turn on the DMX (probe may have been changed).

WARNING

Any measurement observed, when overrange (?) indicator (11) and display (10) are flashing, is invalid.

c. When the display (10) indication and the question mark (?, overrange indicator, 11) flash an overrange condition has been detected by the DMX. An overrange condition is detected when the measured thickness exceeds 9.999 inches. During an overrange condition, the display indicates the last four digits of the measured thickness. For example, measured thickness is 10.493", display flashes 0.493; however, the operator does not know if measured thickness is 10.493", 20.493", etc.

3-24. MATERIAL MODE OPERATING PROCEDURE. When the material mode is selected, the display (10) indicates the last acoustic velocity to which the DMX was calibrated both when the CAL indicator (18) is lighted or out. (If CAL indicator is lighted, Increment pushbutton switch (22) and Decrement pushbutton switch (23) can be used to change the acoustic velocity. The DMX must then be recalibrated.) To select the material mode of operation, depress the Function pushbutton switch, as many times as required, until the carat under MAT'L (4) is lighted.

3-25. NORMAL MODE OPERATING PROCEDURE. When the normal mode is selected, the display (10) indicates the thickness of the material being measured.

In addition, when the normal mode is selected, the DMX can be configured to light the Alarm indicator (13) and the display to flash when the measured thickness is below the LO SET (8) low limit set point or above the HI SET (9) high limit set point. To operate the DMX in the normal mode, proceed as follows:

a. If necessary, perform the wake-up (auto zero) procedure (refer to paragraph 3-14).

b. If necessary, perform the required DMX calibration procedure (refer to paragraph 3-16 or 3-20).

c. Insure that carat under NORM (5) is lighted. If not, depress the Function pushbutton switch (21), as required, until the carat under NORM is lighted.

NOTE

If the alarm function is not required, set the low level and high level set points to 0.000" (000.0 mm).

d. If necessary, enter the low limit set point as follows:

1. Depress the Function pushbutton switch (21), as required, until the carat under LO SET (8) is lighted.

2. Depress the CAL pushbutton switch (1) once. Observe that the CAL indicator (18) lights.

3. Using the Increment pushbutton switch (22) and/or Decrement pushbutton switch (23), as required, increment or decrement the display (10) until the display indicates the desired low level set point.

4. Depress the CAL pushbutton switch (1) once. Observe that the CAL indicator (18) goes out. The low limit set point is now "locked" in the DMX.

e. If necessary, enter the high limit set points as follows:

1. Depress the Function pushbutton switch (21), as required, until the carat under HI SET (9) is lighted.

2. Depress the CAL pushbutton switch (1) once. Observe that the CAL indicator (18) lights.

3. Using the Increment pushbutton switch (22) and/or Decrement pushbutton switch (23), as required, increment or decrement the display (10) until the display indicates the desired high level set point.

4. Depress the CAL pushbutton switch (1) once. Observe that the CAL indicator (18) goes out. The high level set point is now locked in the DMX.

f. Insure that carat under NORM (5) is lighted. If not, depress the Function pushbutton switch (21), as required, until the carat under NORM is lighted.

g. To measure the thickness of the material for which the DMX is calibrated, apply small amount of couplant to the material, and couple the probe to the material. Observe that the Coupling indicator (17) lights. The display (10) indicates the thickness of the material.

3-26. HIGH SPEED MODE OPERATING PROCEDURE. When the high speed mode is selected, the display (10) holds and indicates the minimum thickness measured for approximately three seconds or until a small thickness is measured. The high speed mode can be used to scan or survey a piece for minimum thickness. To operate the DMX in the high speed mode, proceed as follows:

NOTE

Operation of the DMX in the high speed mode depletes the batteries approximately four times faster than the normal mode.

a. If necessary, perform the wake-up (auto zero) procedure (refer to paragraph 3-14).

b. If necessary, perform the required DMX calibration procedure (refer to paragraph 3-16 or 3-20).

c. Depress the Function pushbutton switch (21), as required, until the carat under HI SPD (6) is lighted.

d. To measure the minimum thickness of the material which the DMX is calibrated, apply thin layer of couplant to area of material surface that is to be measured, and couple the probe to the material. Observe that the Coupling indicator (17) lights. Slowly slide probe over area to be tested for minimum thickness. The display (10) holds and indicates the minimum thickness measured for approximately three seconds or until a small thickness is measured.

3-27. NORMAL DIFFERENTIAL MODE OPERATING PROCEDURE. When the normal differential mode is selected, the display (10) indicates the difference between the measured thickness and a preset nominal value. This difference is shown as a + or - (12). This mode is useful for performing quick quality control checks. To operate the DMX in the normal differential mode, proceed as follows:

a. If necessary, perform the wake-up (auto zero) procedure (refer to paragraph 3-14).

b. If necessary, perform the required DMX calibration procedure (refer to paragraph 3-16 or 3-20).

c. Depress the Function pushbutton switch (21), as required, until the carats under NORM (5) and DIFF (7) are both lighted.

d. Enter the nominal value as follows:

1. Depress CAL pushbutton switch (1) once. Observe that CAL indicator (18) lights.

2. Using the Increment pushbutton switch (22) and/or the Decrement pushbutton switch (23), as required, increment or decrement the display (10) until the display indicates the desired nominal thickness value.

3. Depress the CAL pushbutton switch (1) once. Observe that the CAL indicator (18) goes out. The nominal thickness value is now "locked" in the DMX.

e. To perform measurements on material for which the DMX is calibrated, apply a small amount of couplant to the material, and couple the probe to the material. Observe that the Coupling indicator (17) lights. The display (10) indicates the difference between the measured value and the preset nominal value as a + or - number.

3-28. HIGH SPEED DIFFERENTIAL MODE OPERATING PROCEDURE. When the high speed differential mode is selected, the display (10) holds and indicates the maximum negative difference between the measured thickness and preset nominal value for approximately three seconds or until a greater difference is detected (whichever occurs first). To operate the DMX in the high speed differential mode, proceed as follows:

a. If necessary, perform the wake-up (auto zero) procedure (refer to paragraph 3-14).

b. If necessary, perform the required DMX calibration procedure (refer to paragraph 3-16 or 3-20).

c. Depress the Function pushbutton switch (21), as required, until the carats under HI SPD (6) and DIFF (7) are both lighted.

d. Enter the nominal value as follows:

1. Depress CAL pushbutton switch (1) once. Observe that the CAL indicator (18) lights.

2. Using the Increment pushbutton switch (22) and/or the Decrement pushbutton switch (23), as required, increment or decrement the display (10) until the display indicates the desired nominal thickness value.

3. Depress the CAL pushbutton switch (1) once. Observe that the CAL indicator (18) goes out. The nominal thickness value is now locked in the DMX.

e. To perform measurements on material for which the DMX is calibrated, apply thin layer of couplant to area of material surface that is to be measured, and couple probe to the material. Observe that the Coupling indicator (17) lights. Slowly slide probe over area to be tested. The display (10) holds and indicates the maximum negative difference between the measured thickness and the nominal thickness for approximately three seconds or until an greater difference is detected (whichever occurs first).

3-29. MAKING THICKNESS MEASUREMENTS

3-30. Once the proper probe has been selected and the DMX is calibrated, the measuring process is extremely simple. One merely applies couplant to the surface to be measured, couples the probe via the couplant to the material to be measured, and observes the display (10, figure 3-1) indication. Some technique is required for proper use of the probe. It must be held steadily, and in firm contact with the material to be measured. It is often possible to cause a one or more count change in the thickness reading by varying the pressure with which the probe is held in contact with the material to be measured. With greater pressure, the couplant layer becomes thinner and the thickness reading decreases. In addition to the general warnings and ultrasonic thickness measurements warnings contained in the front of this manual, the surface conditions and temperature of the material being measured affect the accuracy of the measurements as described in the following paragraphs.

3-31. SURFACE CONDITIONS

3-32. For best results, both the front and back walls of the material to be measured should be smooth surfaced and free from rust or corrosion. Any loose material on the surface, such as flaking or scale, will impede accurate measurement and should be removed. The walls should also be parallel for best results, although measurements on curved surfaces are entirely feasible and rather common. (See, for instance, Table 1-2.)

3-33. TEMPERATURE

3-34. Variations of temperature will affect the readings made with the DMX. The effect is due both to change in instrument calibration with temperature shift (slight) and to change in material sound velocity with heating or cooling of the material to be measured. To assure accuracy, the DMX should always be calibrated at the temperature it will be operated at using a test piece at the measurement temperature. Hitempco couplant (refer to paragraph 3-7) should be used when testing hot test pieces, over 150°F (65°C).

3-35. BATTERY CHARGER OPERATION

3-36. The optional battery charger assembly provides the means to recharge the DMX batteries when the battery pack assembly installed in the DMX or when the battery pack assembly is removed from the DMX. The conditions of the charge of the DMX batteries is indicated by the low battery indicator (14, figure 3-1). When the low battery indicator lights, the charge remaining on the batteries is sufficient to provide only one hour (maximum) of operation. If the DMX is operated for more than one hour with the low battery indicator lighted, the reduced battery voltage will affect stability and a drift in calibration will occur resulting in incorrect readings. After a long discharge, the DMX will cease to operate. Such long discharging of the batteries is not recommended since it will limit battery life. The battery charger assembly contains a battery charger circuit which contains protective circuitry. This protective circuitry prevents the battery charger assembly from damaging the batteries by over-charging, or incorrect polarity. Therefore, it is permissible although not recommended, to charge the batteries for extended periods of time. To use the battery charger assembly, proceed as follows:

CAUTION

It is recommended that the battery charger assembly always be first connected to the DMX before connecting the battery charger assembly to 115/230 VAC power line. Damage to the battery charger assembly DMX may result if the battery charger assembly is connected to the wrong AC (power lines) voltage source. ALWAYS check the position of the battery charger assembly voltage selector switch prior to connecting the battery charger assembly to the AC voltage source.

a. Remove battery pack assembly battery charging connector cover (25, figure 3-1) from battery pack assembly battery charger connector (26, figure 3-1).

b. Connect the battery charger assembly cable to the battery pack assembly battery charger connector (26, figure 3-1).

c. Connect the battery charger assembly AC line cord to the AC voltage source determined by the position of the battery charger assembly voltage selector switch.

3-37. BATTERY CARE

3-38. The five nickel-cadmium (NiCad) batteries used in the DMX require proper care and attention if full life and operating time are to be obtained from them. With proper care, the life of the batteries can be stretched to hundreds of charge/discharge cycles. Abuse will cause short life and less than rated operation times due to the decay in battery charge capacity. When recharging the batteries allow approximately 1.5 times as much time for recharging as was used to discharge. Internal circuits of the battery charger assembly will prevent damage from overcharging. In some instances, one battery of the five batteries may experience greater discharge than the rest of the batteries in the string. If only minimum amounts of recharge time are allowed, this single battery will never be completely recharged. Over a period of time, this will tend to reduce the charge in the battery, until finally, none remains and the battery is dead. The dead battery affects the operation and charging of the others in the string, and can prevent proper charging. The capacity of the batteries varies inversely with the discharge rate. That is to say, the faster the current drain from the batteries, the lower the obtainable capacity of the batteries. For example, a battery may have a capacity of 2 Ampere-hours when discharged at a rate of 0.25 Ampere, but may have only a 1.5 Ampere hour capacity if more rapidly discharged at a rate of say 1.0 Ampere. Temperature also affects the capacity of the batteries; the lower the temperature, the lower the capacity. Over a period of time, the batteries will age and their capacity reduce. Long discharging or allowing the batteries to remain discharged for long periods will decrease battery life. Self-discharge is slight; a shelf-life of sixty days can be expected from new batteries.

3-39. BATTERY REPLACEMENT (See figure 2-1)

3-40. To remove or replace the batteries, proceed as follows:

a. Using the wrist strap key (23, figure 3-1) or a screwdriver, loosen the two captive screws (see figure 2-1) that secure the battery pack assembly (see figure 2-1) to the DMX1 case assembly (see figure 2-1).

b. Carefully pull battery pack assembly out of DMX1 case assembly.

c. Remove five batteries (see figure 2-1) from battery pack assembly.

d. Install five fully charged NiCad or five new alkaline batteries in the battery pack assembly. Insure that batteries are installed with proper polarities (see figure 2-1). Do not install battery pack assembly in the DMX1 case at this time, proceed to the cold start-up procedure of paragraph 3-12.

3-41. IN CASE OF DIFFICULTY

3-42. If readings of correct thickness can not be obtained with an otherwise properly operating DMX, the problem most likely lies (literally) inside the test piece. The internal structure of some materials causes ultrasound to be severely attenuated and scattered, thereby preventing pulse-echo measurement. Other materials, like fiberglass, have many internal layers which all tend to reflect the sound, causing a confusing number of echoes. The best way to determine the nature of the difficulty is to use a universal flaw/thickness instrument to measure the same material. From the indications on the CRT screen of the universal/flaw thickness instrument, a trained operator can analyze the problems the DMX is encountering. Your local Krautkramer Branson field sales engineer or representative can assist in this regard. NOTE: If there is any question concerning the proper operation of the DMX, DO NOT USE THE DMX, and contact Krautkramer Branson or your local field sales engineer, representative, or distributor.

CHAPTER 4

THEORY OF OPERATION

4-1. INTRODUCTION

4-2. This chapter contains brief descriptions of ultrasonics, pulse-echo measurements, sound (or acoustic) velocity, echo timing, and DMX echo timing measurements. For more detailed information, refer to textbooks and/or industry specifications on the subject of ultrasonic testing.

4-3. ULTRASONICS

4-4. Ultrasonics refers to sound above the range of human hearing, initially, this meant those frequencies just above approximately 20 KHz, but modern ultrasonic instruments operate at frequencies up to 25 MHz. Ultrasound can be propogated with low loss in most materials that are good conductors of sound, such as metals, water, and most other liquids and solids. Compared to the propagation loss through liquids or metals, ultrasound propagated through gas or air is greatly attenuated. At the boundary between a solid and a gas, little ultrasound can be transmitted; most of the sound energy is reflected. This phenomenon is important in the application of ultrasonics to material testing, particularly to ultrasonic thickness measurements using the pulse-echo method.

4-5. PULSE-ECHO MEASUREMENTS

4-6. Measurement of thickness with the DMX is accomplished with the pulse-echo method. Probably the most familiar examples of pulse-echo measurement are radar and sonar. In radar, a radio wave pulse is emitted from an antenna and propogates until striking a reflecting target. The pulse is reflected back to its origin, where it is received and detected. By knowing the rate at which the pulse traveled through the atmosphere and the time interval between its departure and return, the distance at which the reflecting target lies from the antenna can be easily found. Sonar functions in a similar manner, using low audio frequency pulses and water as the propagation medium. As in the preceding examples, thickness measurement is accomplished with ultrasonics by using the pulse-echo method (see figure 4-1). A pulse of ultrasound is emitted by a probe which is coupled to the test piece to be measured. The couplant placed between the probe and the test piece couples the ultrasound generated by the probe to the test piece. The ultrasound enters the test piece and travels through it until reaching the backwall. Because the backwall forms a boundary between solid and gas or liquid, i.e., the test piece and the atmosphere or liquid, almost all the energy will be reflected back towards the probe. In the intervals between pulsings, the probe acts as a receiver, listening for the returning echoes. The time interval between emitted pulse and received reflected echo is proportional to twice the thickness of the testpiece, since the sound has made a round trip. Therefore, if the speed at which the sound traveled in the test piece is known, the thickness of the test piece can be computed.

4-7. SOUND (MATERIAL) VELOCITY

4-8. The speed at which ultrasound travels in a substance varies with the modulus of elasticity, Poisson's ratio, density of the material, temperature of the material, and also with the nature of the wave motion of the sound propagation. Changes in temperature and grain structure and orientation also affect the sound velocity of materials. Since what any ultrasonic thickness measuring device really measures is a time interval between echoes which is subsequently converted to a thickness measurement by multiplication by the sound velocity, it is crucial that the sound velocity be accurately known and uniform, and that it remain constant from one sample of the material to the next. Fortunately, it is generally true for most metals that the sound velocity remains reasonably constant among similar alloys. However, changes in the sound velocity do cause changes in thickness readings made with any ultrasonic thickness gage. The greater the resolution of the instrument doing the measuring, and the greater the distance being measured, the more the effect of changes in sound velocity will be noticed. Because the DMX has high resolution (0.001 in./0.1 mm) it is possible that variations in thickness readings will be noted between two test pieces that have identical physical thickness as measured by a micrometer. This is not due to malfunction on the part of the DMX, but arises from the physical fact that there is a slight difference in sound velocity between the two test pieces, sufficient in this case to cause the DMX to be improperly calibrated for one piece when properly calibrated for the other. With plastics, this variation from piece to piece of what would appear to be identical material is more pronounced, and will in many cases become the limiting factor in determining what accuracy may be obtained with ultrasonic thickness measurements. Therefore, the DMX must be periodically recalibrated during testing.

4-9. It should also not be inferred that before an ultrasonic thickness gage such as the DMX may be used, it will always be necessary to know the sound velocity of a material. The sound velocity may be determined empirically by first measuring the actual thickness of a testpiece, then adjusting the sound velocity calibration control of the DMX (MAT'L) until the correct thickness reading is obtained. The DMX can then be switched to show the material sound velocity for which it has just been calibrated. This number can be noted, and used again as a target value for subsequent calibration of the DMX for measurement of the same material. Final calibration is always best done with samples of the actual material being measured. These samples should be accurately measured with common measuring instruments and the DMX adjusted to produce the correct readings on these samples. This method prevents other variables, such as instrument drift, temperature change, and material differences from affecting the results.

4-10. ECHO TIMING

4-11. At the nominal frequency of 10 MHz, the wavelength of a longitudinal (or compression) wave of ultrasound in steel is approximately 0.020 in.

(0.5 mm). This means that in the time it takes for one cycle of the returning echo signal to occur, the sound will have traveled about 0.020 in. (0.5 mm). Since the DMX is able to measure accurately in increments of 0.001 in. (0.1 mm), it becomes apparent that the timing of the interval between echo signals must be done in increments of much less than one cycle of the echo signal. This means that variations in either the phase of the echoes or their amplitude can cause considerable error in timing. This condition is shown in figures 4-2 and 4-3. To greater appreciate the precision of the timing circuits of the DMX, consider the distance which light will travel in the same time that ultrasound will travel 0.0001 in. in steel. Since the velocity of longitudinal waves of ultrasound in steel is nominally 2.3×10^5 in/sec., the time (T) required for travel of 0.0001 in. is:

$$T = \frac{1 \times 10^{-4} \text{ in.}}{2.3 \times 10^{5} \text{ in./sec.}}$$

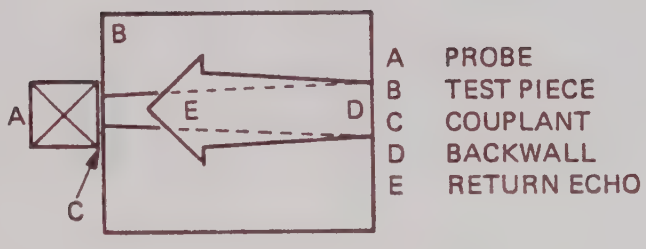
$$= 4.3 \times 10^{-10} \text{ sec.}$$

If the velocity of light is 186,000 miles/second, in this same time light will have traveled:

$$= \frac{1 \times 10^{-4} \times 1.86 \times 10^{5} \times 5.28 \times 10^{3} \times 1.2 \times 10^{1}}{2.3 \times 10^{5}}$$

$$= 5.1 \text{ inches (!)}$$

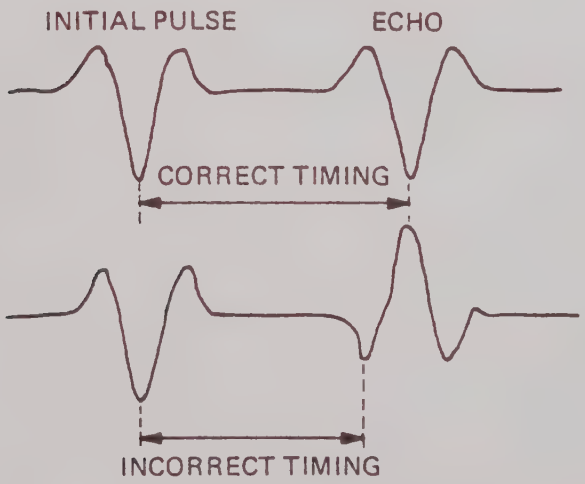
This result is somewhat of a surprise to most people. It is, however, indicative of the accuracy of the timing circuits in the DMX.



PROBE (A) IS COUPLED TO TESTPIECE (B) THROUGH COUPLANT (C). INITIAL PULSE FROM PROBE TRAVELS THROUGH TESTPIECE TO BACKWALL (D) WHERE IT IS REFLECTED BACK (E) TO THE PROBE.

Figure 4-1. Pulse-Echo Measurements

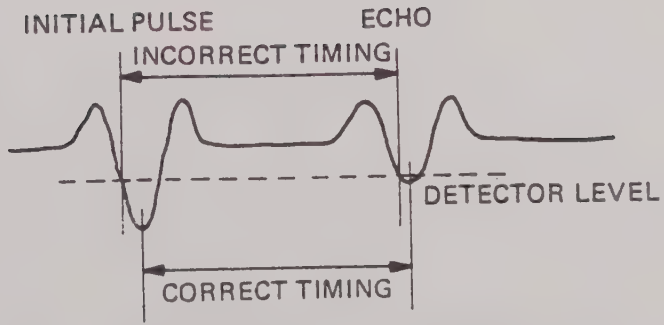
NO PHASE REVERSAL PRODUCES CORRECT TIMING.



PHASE REVERSAL BETWEEN SIGNALS CAUSES LARGE ERROR IN TIMING.

THE ECHO FROM THE BACKWALL IS ALWAYS IN REVERSED PHASE FROM THE INITIAL PULSE OR THE FRONTWALL ECHO. THIS WILL PRODUCE AN ERROR IN TIMING UNLESS CORRECTION IS MADE. THE DMX HAS A UNIQUE PHASE CORRECTION CIRCUIT WHICH COMPENSATES FOR THIS AND ELIMINATES THE ERROR IN TIMING.

Figure 4-2. Incorrect Timing Caused by Phase Inversion of Echo



VARIATIONS IN AMPLITUDE CAN ALSO CAUSE ERRORS IN TIMING. THE LOWER AMPLITUDE CYCLE DOES NOT REACH THE DETECTOR LEVEL UNTIL ALMOST AT ITS CREST. THE HIGHER AMPLITUDE CYCLE TRIGGERS THE DETECTOR AHEAD OF THE CREST. AN ERROR IN TIMING IS PRODUCED – NOTE THE DIFFERENT LENGTH OF THE UPPER AND LOWER DISTANCES.

Figure 4-3. Incorrect Timing Caused by Amplitude Variations of Echoes

CHAPTER 5

MAINTENANCE INSTRUCTIONS

5-1. INTRODUCTION

5-2. This chapter contains the preventive maintenance and corrective maintenance instructions for the DMX.

5-3. PREVENTIVE MAINTENANCE

5-4. Preventive maintenance consists of a visual inspection and cleaning, which if performed on a regular basis, extends the life of the DMX and insures it is ready for use when needed.

5-5. VISUAL INSPECTION

5-6. The first step of a visual inspection is to remove the battery pack assembly (refer to paragraph 3-39). Inspect the batteries for damage, corrosion, and leakage. Inspect the DMX for damage, corrosion, and cleanliness. Inspect DMX case assembly mounted components for proper mechanical operation and for mounting security.

CAUTION

Never use esters or ketones to clean the DMX as these solvents discolor plastic parts.

5-7. CLEANING

5-8. The following paragraphs contain the instructions to clean the exterior and interior of the DMX and to clean the probe.

5-9. EXTERIOR CLEANING. Clean the exterior of the DMX including the display but exluding the connectors with a clean damp cloth and a mild detergent solution. Clean the connectors with a clean cloth dampened with alcohol.

5-10. INTERIOR CLEANING. A vacuum cleaner is recommended to clean the interior of the DMX. A small non-metallic nozzle must be used and care taken not to damage components with the nozzle.

CAUTION

Autoclaving will damage the probe. Do not spray cleaner of any type on the probe.

5-11. PROBE CLEANING. Clean the probe(s) with a clean cloth dampened with alcohol. Never use autoclaving or spray cleaners of any type.

5-12. CORRECTIVE MAINTENANCE

5-13. Since the DMX contain hybrid integrated circuits and requires special test equipment and software to test and adjust the DMX internal circuits, corrective maintenance in the field is limited to replacing the probe assembly and probe cable assembly, probe and cable assembly, batteries and/or battery pack assembly (refer to paragraph 3-39). If replacing these components does not return the DMX to an operational condition, return the DMX to Krautkramer Branson, P. O. Box 350, Lewistown, Pennsylvania 17044 for repair or contact your local representative.

CHAPTER 6

PARTS LISTS

6-1. INTRODUCTION

6-2. This chapter contains the applicable parts lists and parts location diagrams. The applicable parts location diagram precedes the corresponding parts list. In addition, where applicable, the parts location diagrams reference the figure number for the indexed assembly detailed breakdown and/or reference the figure number of the next higher assembly.

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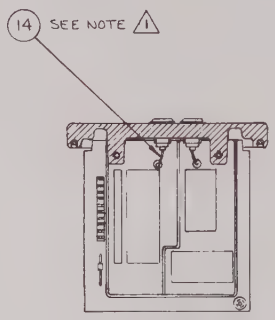
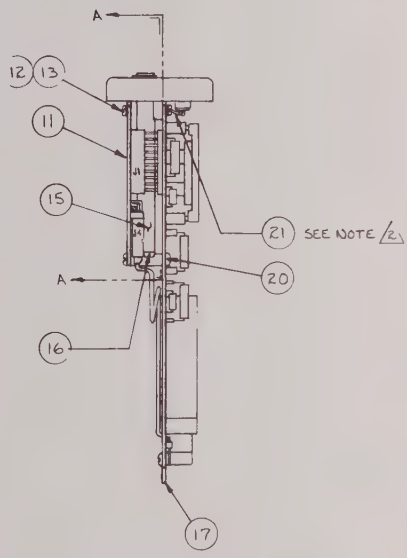


SECTION A-A

SHIELD COVER REMOVED FOR CLARITY



SIDE VIEW

WITH CASE ASSEMBLY AND BATTERY PACK ASS'Y REMOVED

NOTES:

1. SOLDER BUSS WIRE TO LEMO CONNECTORS AND RESPECTIVE POINTS ON P.C. BOARD AS SHOWN.
2. SOLDER BUSS WIRE & LEADS FROM R12 TO PC BOARD AFTER ASSEMBLING PC BOARD TO FRONT PANEL.

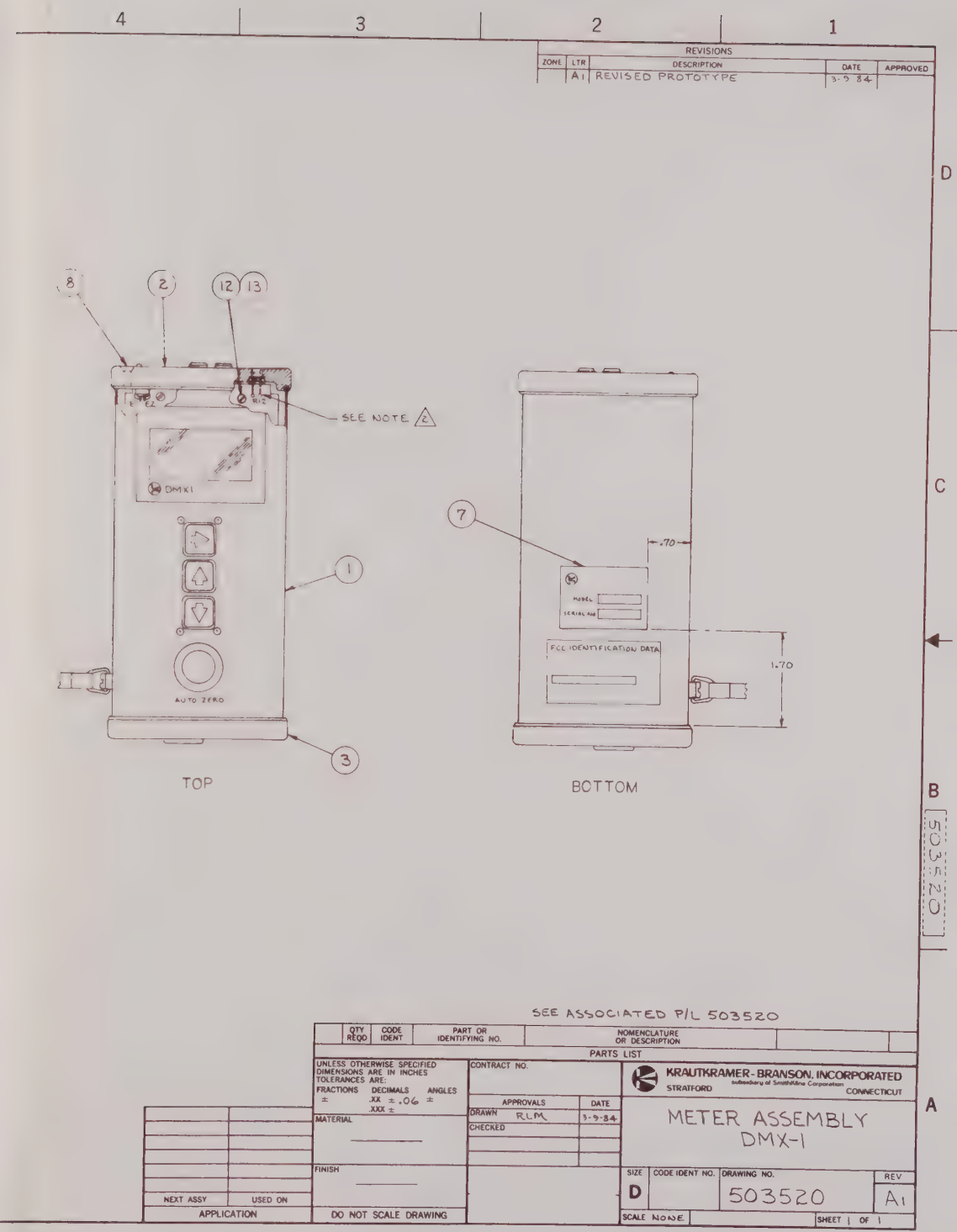


Figure 6-1. DMX1 Meter Assembly Parts Location Diagram (503520, Rev. A1)

PARTS LIST	KRAUTKRAMER-BRANSON, INCORPORATED subsidiary of SmithKline Corporation STRATFORD CONNECTICUT	CODE IDENT	PL 503520	REV LTR A1 DATE
LIST TITLE Meter Assembly, DMX-1				SHEET 1 OF 2 SHEETS

ITEM NO.	QTY -001	QTY -002	QTY -003	QTY -004	QTY -005	DRAWING OR DOCUMENT NUMBER	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	REF DES
1.	1					503470	022-503-470	Case Assy.	
2.	1					503540	022-503-540	Front Panel Sub-Assy.	
3.	1					503510	022-503-510	Battery Pack Assy.	
4.	5					Everready CH500H	021-010-064	Battery, Nicad AA	
5.									
6.									
7.	1					607976	021-607-976	Label, Serial No.	
8.	2					6-32 x 3/4 LG Screw	021-350-062	Cap Screw, #6-32 x 3/4 LG Flathead Socket, B.O. Finish	
9.	REF					503560	022-503-560	Battery Charger Assy.	Accessory Item
10.								Software, Operating DMX-1	

REV																											
SHEET																											
REV STATUS OF SHEETS																											

NEXT ASSY			USED ON																								
APPLICATION																											

REV	REV AUTH NO.	CHK	REV	REV AUTH NO.	CHK	REV	REV AUTH NO.	CHK
A1	Revised Prototype							
A	Prototype							

DR DM
DATE 2/14/84
CHK GRB
DATE 2/15/84
APPD
DATE

Table 6-1. DMX1 Meter Assembly Parts List (PL503520, Rev. A1)

PARTS LIST	KRAUTKRAMER-BRANSON, INCORPORATED subsidiary of Smith Kline Corporation STRATFORD CONNECTICUT	CODE IDENT	PL 503520	REV LTR A1 DATE
LIST TITLE Meter Assembly, DMX-1				SHEET 2 of 2

ITEM NO.	QTY -001	QTY -002	QTY -003	QTY -004	QTY 005	DRAWING OR DOCUMENT NUMBER	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	REF DES
11.	1					253710	022-253-711	Pulser/Receiver P.C. Bd. Asy	
12.	4						021-350-063	#2-56 x 1/4 LG P.H.M.S.	
13.	4					Din 6798-A M2	021-354-035	Washer, Lock - M2	
14.	A/R							Wire-#20/1, Solid, Bus	
15.	1					607938	021-607-938	Shield Cover	
16.	1						021-350-100	#4-1/8 LF Sheet Metal Screw Type A or AB	
17.	1					253700	022-253-701	LCD/CPU P.C. Bd. Assembly	
18.									
19.									
20.	1						021-350-066	Nylon #4-40 x 3/16 LG P.M.H.S.	
21.	A/R							Wire, #22/1 Solid, Bus	

Table 6-1. DMX1 Meter Assembly Parts List (PL503520, Rev. A1) (Cont'd)

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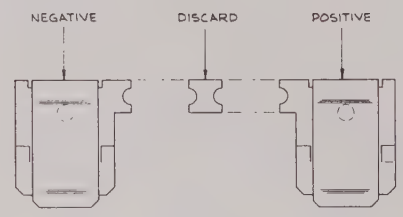
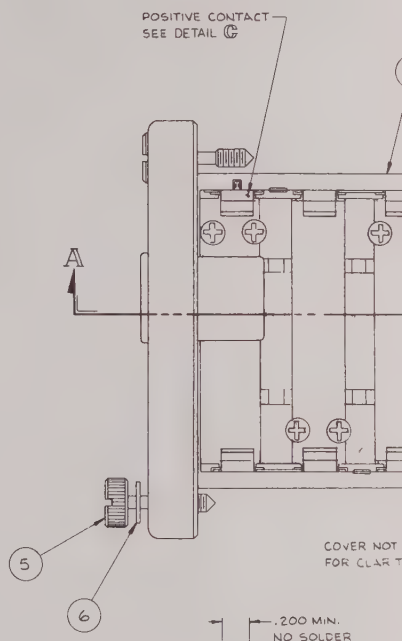
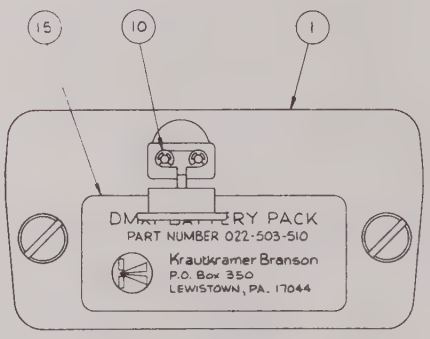


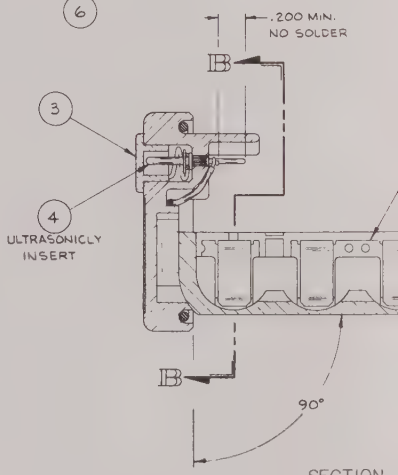
DETAIL C
SCALE : 4/1

BREAK APART (1) ONE CONTACT SPRING AS SHOWN TO FORM POSITIVE AND NEGATIVE CONTACTS SEE NOTE 1



COVER NOT
FOR CLAR





SECTION
COVER NOT S
FOR CLARITY

NOTES

1. ASSEMBLY PROCEEDURE :
   A - SOLDER WIRE TO CONTACTS
   B - FEED WIRE THRU HOLE IN BATTERY TRAY
   C - INSERT CONTACT INTO GROOVE IN TRAY
   D - PRESS WIRE INTO SLOTS IN BOTTOM AND BACK END OF TRAY
   E - CEMENT TRAY TO END PANEL W/LOCTITE 416
2. APPLY 416 IN AREAS OF GROOVE INDICATED BY # ONLY

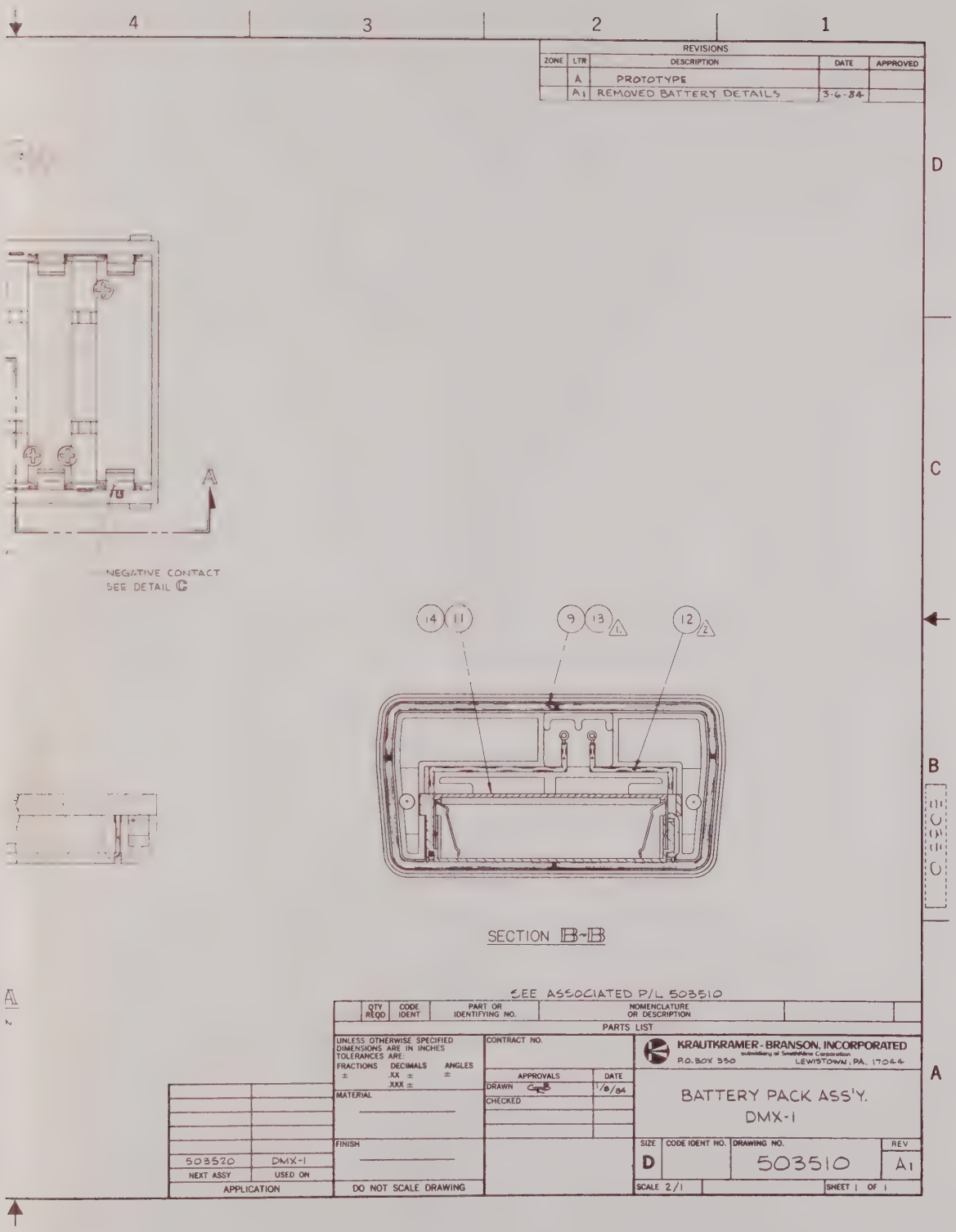


Figure 6-2. DMX1 Battery Pack Assembly Parts Location Diagram (503510, Rev. A1)

PARTS LIST	KRAUTKRAMER-BRANSON, INCORPORATED subsidiary of SmithKline Corporation STRATFORD CONNECTICUT	CODE IDENT	PL 503510	REV LTR A1 DATE
LIST TITLE Battery Pack Assy.				SHEET 1 OF 2 SHEETS

ITEM NO.	QTY -001	QTY -002	QTY -003	QTY -004	QTY -005	DRAWING OR DOCUMENT NUMBER	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	REF DES
1.	1					607947	021-607-947	Battery End Panel	
2.	1					607945	021-607-945	Battery Tray, Molding	
3.	1					607942	021-607-942	Battery Pin Cover	
4.	2					607941	021-607-941	Battery Pin	
5.	2					Promptus Elect. Hdwe. #168-11-SS-6-32Z	021-350-064	Panel Mount Screw, 6-32 x 9/16	
6.	2					Seastrom 5613-18-31 #4-.317 OD x .125 ID	021-354-099	Washer, Neoprene	
7.	5					607937	021-607-937	Spring, Contact	
8.									
9.	1					Service Seal "O"Ring #2-038-N674-70	021-235-017	Gasket, O-Ring	
10.	2					Truarc # X-5133-6	021-127-067	Retaining Ring	

REV																													
SHEET																													
REV STATUS OF SHEETS																													

503520		DMX-1		A1		Revised Prototype																							
NEXT ASSY		USED ON		A		Prototype																							
APPLICATION				REV		REV AUTH NO.		CHK		REV		REV AUTH NO.		CHK		REV		REV AUTH NO.		CHK									

DR DM
DATE 2/14/84
CHK GRB
DATE 2/15/84
APPD
DATE

Table 6-2. DMX1 Battery Pack Assembly Parts List (PL503510, Rev. A1)

Table 6-2. DMX1 Battery Pack Assembly Parts List (PL503510, Rev. A1) (Cont'd)

PARTS LIST

KRAUTKRAMER-BRANSON, INCORPORATED
Subsidiary of Smallbone Corporation
STRATFORD CONNECTICUT

CODE IDENT PL 503510

REV LTR DATE A1

SHEET 2 of 2

LIST TITLE

Battery Pack Assy.

ITEM NO.	QTY -001	QTY -002	QTY -003	QTY -004	QTY -005	DRAWING OR DOCUMENT NUMBER	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	REF DES
11.	1					607964	021-607-964	Battery Tray Cover, Molding	
12.	AR							Wire, 22/1 Stranded-Yel.	
13.	AR							Loctite #416 Adhesive	
14.						607970	021-607-970	Label, Battery Pack	
15.						607969	021-607-969	Label, End Panel	

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